ABSTRACT

Thesis Title:	HOLOGRAM, HEADING INTO THE LIGHT: EXPLORING EMBODIMENT, IDENTITY, AND DIGITAL MOTION CAPTURE.
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As digital technologies increasingly shape perception, interaction, and representation, dance artists are uniquely positioned to interrogate their impact on embodied experience. *Hologram*, my MFA thesis project, investigates how motion capture tools such as Rokoko and Unity mediate the expressive capacity of the body and influence the construction of identity in performance. This interdisciplinary research draws on rehearsal-based inquiry, digital experimentation, and somatic practice to examine the feedback system I call the *Body-Machine Loop*: a dynamic in which digital tools both discipline and are shaped by the bodies that use them.

The process began with the collection of motion capture data from 35 dancers across various geographies, forming a digital archive of improvisatory material. Collaborating with a cast of four performers, we mined this archive using miscalibration, improvisation, and kinesthetic empathy to generate both live and

digital choreography. The resulting performance explored glitch aesthetics, avatar logic, labor and reliability within digital systems, and the porous boundary between physical and virtual selves.

The written thesis contextualizes the performance across five chapters: Chapter 1 introduces key definitions and methods; Chapter 2 frames the theoretical groundwork for digital embodiment and the Body-Machine Loop; Chapter 3 analyzes the construction and performance of *Hologram*; Chapter 4 documents technical strategies, failures, and workarounds; and Chapter 5 extends the research to issues of surveillance, labor, and digital materiality. Ultimately, this project argues for the choreographic and critical potential of glitch, the liveness of digital bodies, and dance as a methodology for investigating the sociopolitical logics embedded in contemporary technologies.

HOLOGRAM: HEADING INTO THE LIGHT: EXPLORING EMBODIMENT AND INDENTITY, AND DIGITAL MOTION CAPTURE

By

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We keep trying to transcend ourselves and our own interests, and yet the more the world becomes inhabited by our tools and technologies, the more unlikely it is that humanity will encounter anything in the world around it that is not, in the last analysis, they themself in different disguise.[1]

Introduction

As digital technology, big data, and digital media platforms become more prominent in western popular culture, close behind them are the implications they bring. Like the opening quote suggests, the tools we make often reflect both important aspects of culture and human interaction in unique ways, and what we can learn about ourselves by engaging with it. In the process of developing my thesis performance at the culmination of my MFA studies, I explored ways in which digital tools influence the world around us and can participate in sculpting an individual's sense of identity, and give frameworks for engaging with the world. Digital media has given me many unique opportunities for exploring digital performance paradigms. These insights offer new perspectives We;into the ways that digital technologies mediate the embodied experience. My initial area of research focused on the digitization of human expressivity, specifically focusing on what information is retained and prioritized in that process, by utilizing motion capture tools like Rokoko and Unity. Using these tools, I created a vast compendium of movement data from 35 different dancers from around the world by recording their dancing with the Rokoko suits, and then used that data to present a living archive of those dances in *Hologram*, presented at the Spring

[1] Arendt Hannah. 1978. Between Past and Future: Eight Exercises in Political Thought Enlarged ed. New York: Penguin Books.

M.F.A Dance Thesis Concert on the weekend of February 14th-16th, 2025, at The Clarice in the Dance Theater at the University of Maryland, performed by C Macko, Emma Vanderlinde, Emma Young, and Julie Zalalutdinov. The work I presented in this concert explored the vastness of the ways both digital and physical bodies express interiority - a persistent felt sense of self and deep seated feelings that is often the “Me/I” that an individual may self refer to - and the different experiences of embodiment amongst the physical performers and digital avatars in the concert. What changes when those expressions of interiority, of self, come from entities we don’t consider having interiority, like digital performers? How far does a viewer's sense of empathy, kinesthetic or otherwise extend, and how far does a performer's sense of self stretch? Can the digital be as real as the analog world, and how can we make visible all the elements, both material and conceptual, that tend to retreat from view along the way? If our tools are indeed made in our image, whose body was in mind when Rokoko built their suits and designed their digital avatars? What components and materials keep the landscape of our digital archive of dances alive, thrumming, ready to use at any time? And finally, what is lost and what is retained in the digitization of our embodied expressions?

Unity, Rokoko, the Lingo and the Tools

Throughout the document, I’ll be using several terms that bear explanation here, along with some of the more relevant details in how I use them and how they work.

Digital; Digital, for the purposes of this thesis, means any representational medium that is generated, stored, manipulated, and presented by computation. At the hardware level a digital system reduces experience to a rapid series of binary decisions— tiny on/off voltage states that a processor reads billions of times per second, stored as 1 or 0. Each 1 or 0 is a numerical sample of something that was once continuous: a vibration in the air, a movement in space, a beam of light on a sensor. An analog medium (say, the groove of a vinyl LP or the magnetic flux on tape) physically inscribes the entire waveform in an unbroken trace, whereas a digital medium records discrete samples, assigns each a number, and later re-assembles those numbers into output we can see, hear, or feel. Algorithms can then copy, transform, or compress the data—sometimes throwing away imperceptible detail (as with MP3 or JPEG), sometimes preserving every bit in lossless form—but the decisive shift is already present in that first instance of sampling. In short, the digital differs from the analog not because it is electronic (many analog devices run on electricity) but because it translates the fluid into countable units. What we encounter on a screen, in a speaker, or through a motion-capture avatar is therefore a combination of measurements plus mathematical guesswork, an endlessly reproducible proxy, yet never the continuous phenomenon itself.

Unity scene: As stated earlier, I use Unity which is a cross-platform gaming console which can be used to create games or record scenes (much like film), such as the ones I use for the concert. Each Unity scene operates like a meticulously practiced movie scene. I choose the digital avatars, set their locations, give them choreography, sometimes attribute special effects to them (see below).

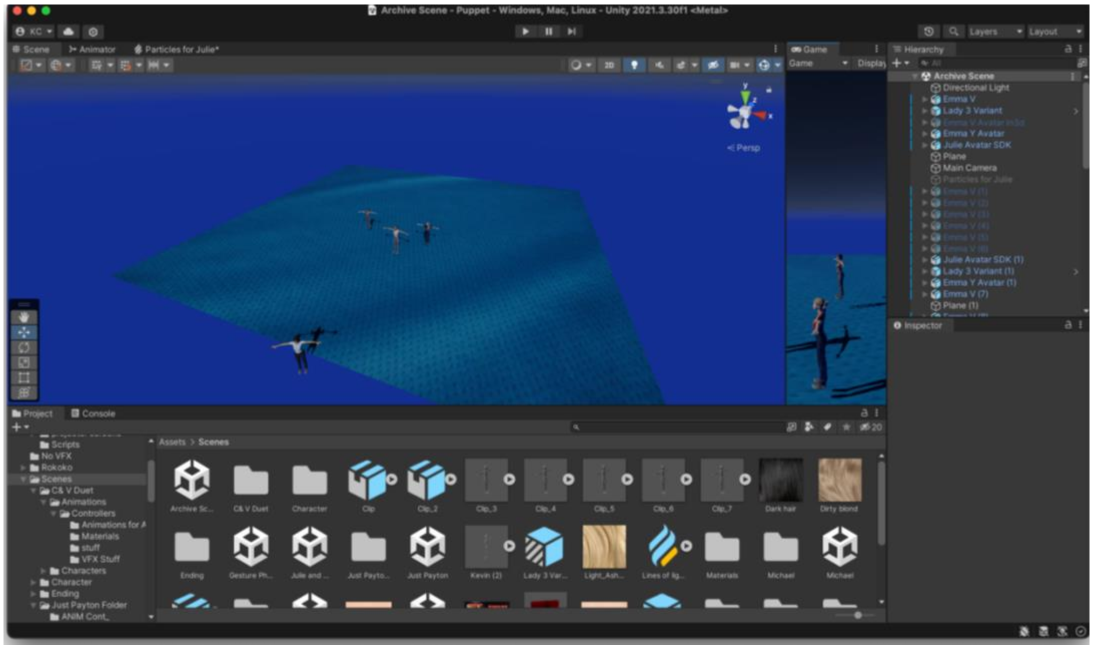

Fig.1

By recording motion capture in Rokoko and importing those clips into Unity and attaching them to specific avatars, I create whole scenes full of dancing avatars who move through digital space, look a certain way, and coordinate a camera to move within that digital space very similar to a camera moving on a live set. From there, I record them and turn them into a video clip that is then projected onto the voile fabric in the theater. A "scene" in this thesis will refer to a projected video recording made in Unity.

Rokoko: Rokoko, as a term, will often stand in for either part or a whole suite of tools (context in writing will make clear which is being referred to) that were used in the rehearsal, production, and performance of *Hologram*. This suite includes:

- Inertial Motion Capture Suits: These suits are worn by the performers, and operate by attached sensors moving with each performer, recording the nature of the movement, and transmitting that data to a router, which then sends that data to a computer.
- Router: The Rokoko router is an electronic device that captures a Wi-Fi signal sent from the Inertial Motion Capture Suits (hereafter referred to as Rokoko suits) and then routes that data to a computer where the Rokoko software is running. It requires a dedicated signal ID and priority network status on the computer it sends to. The router will also send small packets of data back to the suits for connectivity confirmation.
- Rokoko Software: This is a software program that is designed to take the data that comes from the suit and assemble it into the digital movement and animation of a digital avatar in the likeness of the performer wearing the Rokoko suit. It can run on any personal computer, and functions to record movement for both video game animations and for digitally animated film. The movements are recorded very similarly to how someone might record a video on their phone; record while the action is happening, stop recording once it's done, and then save it for later use. These clips can be edited in length, and to some degree the movements can be finessed, and are primarily exported as an FBX file (a standard 3d image file, short for Film BoX) to platforms like Unity, Unreal Engine, or cross platform systems, though users can export as CSV (lists of values in a spreadsheet, essentially) if they choose.

Digital Avatar: For this thesis, a digital avatar refers to a digital representation of a person that can be animated using software like Rokoko, Unity, or Unreal Engine.

IRL/AFK: In Real Life/Away From Keyboard. These terms can be used in common internet and digital media culture language. In Real Life, perhaps self-explanatory, refers to the events of the world of material; bodies, houses, cash, tables and chairs, etc., as opposed to the digitally mediated representations of those things. Away From Keyboard comes from chat websites initially indicating a chat message sent might not be replied to until the recipient got back online. It situates an individual's relationality to the digital world of internet culture's as not subordinate to (Real v False), but as a facet of a multi-modal world in which digital and internet culture are equally real and impactful.

Embodiment: Those who are engaged with the academic or physical practices of performance arts, here specifically dance, will recognize this as a term with many potential meanings, ranging from a stand-in for "authentic" or "believable", "only understood or able to be engaged by utilizing the body", or that something is exemplary or personifies some quality. I honor and recognize that wide array and put forth my usage for this thesis; the actions of a performer which allows a viewer to understand some aspect of the performer's felt interior state. In other words, in watching a performer move, does a viewer feel they understand something about the interiority of the performer, the essence or aura that drives the movement? In Gaga, the improvisational movement practice that undergirds the physical research of my thesis, I often think of embodiment as a sensation state, both of body and mind, that informs and drives the actions, an inside-out approach to engaging in movement.

Improvisation: This is another term with a plethora of meanings. Improvisation, in the context of my research, is approached as an embodied movement practice rooted in the practitioner's internal, felt sense of bodily action—where imagination, anatomical exploration, and external forces such as gravity converge. It functions as a tool for generating movement, cultivating kinesthetic awareness, enhancing anatomical literacy, and deepening the connection between expressivity and personal fulfillment. My methodology draws from my study of Gaga, somatic practices within Western concert dance - such as Bartenieff Fundamentals - and personal exploratory frameworks, including improvisational "scores" I've developed in my own choreographic work and experienced within the processes of other choreographers.

Throughout my research process, I guided cast members to begin from within; to engage improvisation as a responsive, real-time process in which movement and decision-making emerged from their physical, emotional, and spatial experiences. In doing so, improvisation became a means for performers to access and articulate the specificities of their physical movement histories, allowing them to generate material marked by the distinct qualities of who they are and how they move.

One could easily assume that the substance of choreographic thought resided exclusively in the body. But is it possible for choreography to generate autonomous expressions of its principles, a choreographic object, without the body? - William Forsythe[2]

Chapter 1: Choreographic Objects, and their Creators

Moving with the Avatar: Process and Theory

Performer and dancer Emma Vanderlinde zips up her suit and makes sure the straps are in place as I check the signal between the router and my computer. On my laptop's screen, we see a digital avatar that is proportioned to Vanderlinde's height and limb lengths, and as Vanderlinde moves, we both see on screen that Rokoko's digital avatar is moving as she does, confirming that both the signal and sensors are good and working. She nods to me, and I give her the thumbs up to go ahead. Vanderlinde begins to move into a forward fold, and we begin guessing how the digital avatar we're manipulating will move. We're working with a program called Rokoko, which takes live data from our inertial motion capture suit (as opposed to visual capture) that Vanderlinde is wearing. The suit sends that data to the Rokoko software to translate that movement data into a 3D digital avatar (think 3D video game character) model that we're watching onscreen. We've been trying to exploit the program to create glitch.

While there are many ways to think about glitch, we consider glitch as defined by feminist literary critic Legacy Russell as "…an error, a mistake, a failure to function. Within technoculture, a glitch is part of machinic anxiety, an indicator

[2] William Forsythe, "Choreographic Objects," *William Forsythe: Choreographic Objects*, accessed December, 2024, https://www.williamforsythe.com/essay.html.

of something having gone wrong."[3] In our research, we're exploring the power of glitch, its relationship to how we perceive ourselves, and the potential to explore new facets of ourselves by both exploiting and enhancing it. To create glitch in this situation, we've exploited a crucial step in using the motion capture suit; a step called calibration. When calibrating, the person who is wearing the Rokoko suit assumes a specific position called a Calibration Pose—standing upright, feet under hips with arms at their sides—and the suit's embedded instruments measure the values of the sensors at that moment. There are three measurements; *gyroscopic* (referring to rotation), *acceleration* (referring to movement through space), and a *magnetometer* (measuring the distance between each other sensor). When those values are calibrated, the measurements Rokoko receives at that time are set as a baseline for all future incoming data, as the software assumes that the wearer faithfully adopted this pose. When these three systems of measurement are working together, and the user of the suit is properly calibrated, the expected output, the movement of the digital avatar (hereout just "avatar") should be the movements that appear to align with what the user is doing; if the user raises their right arm, throws their leg, does a TikTok dance trend, a viewer should see the avatar doing essentially the same thing. This is essential to the intended use of these Rokoko suits, as they are normally used by creators in the video game and indie animated film industry to create custom animations[4], rather than create animation frame by frame by hand in a program like Blender.

[3] Russell, Legacy. *Glitch Feminism*: *A Manifesto*. London, Verso. 2020
[4] On Rokoko's website, the collection of most prominent users lists Disney, SquareEnix, Netflix, HBO, and Roblox, among others. These are companies who rely heavily on motion capture technologies for their digitally animated materials.

However, I'm a naturally curious person, particularly when someone tells me a rule I don't understand, and Rokoko is full of rules I didn't understand, so when I first began learning about Rokoko and how the calibration system works, I became curious about the way it operates. Multimedia Artist and Professor at UCLA Kate Ladenheim, who first introduced me to this technology in a digital media class, would often have students re-calibrate if their body wasn't in quite the right position, causing Rokoko's avatar to not quite match the actions of the performer. So, I wondered about the limits of "not quite right" calibration; is there a limit? Does the embedded technology restrict calibration positions to within a certain threshold, or can I push the calibration further? Can I be upside down? What about splits?[5] I quickly discovered that the software will calibrate to *any* position during calibration and assume it is "standing normally" in Calibration Pose, which I happily took and ran with. For instance, if Vanderlinde calibrates while in a forward fold, the software interprets her forward fold as neutral, displaying her avatar as standing normally while she is in a forward fold. This means that when Vanderlinde stands upright, the digital avatar appears to be in a deep backbend (Vanderlinde's forward fold => digital body standing; Vanderlinde standing => digital body in a backbend). IRL (in real life), we watch Vanderlinde walk normally while onscreen her avatar waddles along, its torso dragging on the floor behind it like something out of *The Nightmare Before Christmas*. As Vanderlinde penchés, lifting her leg behind her, her digital leg passes straight through the avatar's torso and arcs towards the sky.

[5] In the software development/computer science world, these would be called "edge cases", or usage that is technically possible but far outside intended use.

This glitch feels generative—a chance to explore the boundaries of what the motion capture software can do and to explore action that our real physical bodies could never accomplish. It also gives both the performers and myself a way to test the system's limits, examining how outputs can diverge from the system's purported intention: to faithfully represent a person's motion in a digital landscape. For our research, we record movement sequences with cast members wearing Rokoko suits, then use Unity, a cross-platform game engine, to animate digital characters with these recorded movements. In Unity, we can create whole environments for them and have an entire host of different characters perform the same choreography with their unique shapes, sizes, gender presentations, race, class, etc.

Fig 2

In a very critical way, our cast can see each of their unique movement fingerprints on the movements that they create. Their particular ways of moving brought about by body history, dance training, anatomical differences (both subtle and profound), how familiar they were with the technology, etc. are each represented and re-presented on a vast array of digital bodies that faithfully reenact the movement we record. Part of our rehearsal process was, in fact, to try not only to understand the movement from these recorded movement sequences, but to get a sense of the original performer's essence by watching their movements performed by an avatar, in a similar way that avid viewers of a particular choreographer are able to recognize the style, movement qualities, energetic textures, or movement vocabularies. In a sense, the cast of this work was trying to undo the digitization process, remounting dances by using kinesthetic empathy and the movement logics they have each developed over the course of their dance careers.

We can also add intentional miscalibration of the avatar as another such way of putting a fingerprint on a choreography, in the sense that each miscalibration is slightly different, and the choices each dancer makes in creating their miscalibration were made in that moment and also dependent on the body that forms the miscalibration. Vanderlinde, for example, was drawn to the use of her flexibility and long torso in deciding both the miscalibration position and the movements that resulted in the forward fold miscalibration solo in the performance of *Hologram*. She exploited the features of the miscalibrated avatar, saying "...when we were experimenting, I noticed that having a leg [disconnected] made it look very interesting. And I just wanted to make it do things that I can't do in real life. I like doing, like, unnatural weird movement in the first place because I think it's really interesting and kind of a spectacle in a way. So how much can I turn what I'm doing into a spectacle of that sort?"[6]

Fig 3

I am drawn to dance theorist and historian Susan Foster's thoughts on such a phenomenon here when they write,

> *…[certain previous dances] make a strong claim for considering choreography as necessarily inclusive of the history of the performer's training and cultivation of expertise at dancing. These dances, especially, draw from and rely on knowledge embedded bone-deep in the dancer's physicality – the product of years of dedicated practice to specific aesthetic and social values. They integrate that knowledge seamlessly into the fabric of the dance, or more precisely, the formation of physicality they have undertaken in learning to dance cannot be separated from other aspects of the performance. It is not simply that other bodies, differently trained, might alter the look and impact of the dances, but instead that the dances could not occur without the prior investments that these performers have made in learning to dance.*[7]

When I watch an early glitch calibration by former cast member Kevin Carroll, for example, I can see his essence not only in his movement choices but

[6] Vanderlinde, Emma (performer) in conversation with the author, March 2025
[7] Foster, Susan Leigh. Choreographing Empathy: Kinesthesia in Performance. London: Routledge, 2010.

the way the resulting choreography is glitched based on the miscalibration that he chose in that recording.

In the creation of *Hologram,* one of our areas of research was whether the cast could find these movement fingerprints or essences while mediated through motion capture and digital avatars. The research was supported both by the International Program for Creative Collaboration and Research (IPCCR) and an award from TDPS's Board of Visitors, which took me to both The American Dance Festival (ADF) in Durham, North Carolina to work with established artists, educators, and students and to Orsolina 28, an artist compound in northern Italian town of Moncalvo where a GagaLab was being held. At Orsolina, I was able to work with professional dancers from Batsheva Dance and emerging artists there to study and train with them. My goal at each of these locations was to record motion capture sequences centered on embodiment, somatic practice, and the idea of hologram. For this research, I asked dancers to wear the Rokoko suits and then gave them three prompts:

- In the first round of recording, I asked dancers to dance freely in an improvisatory way, moving how they would like to. This acted as a baseline, allowing me to see how their movement changed with the next prompts.
- In the second round of recording, I asked dancers to actively focus on somatic[8] principles or tools while improvising, either from the practices from the Batsheva workshop, an ADF class, or from their personal dance

[8] Somatics here refer to dance somatic practices. It is a field unto itself, which here refers to the practice of connecting sensation, anatomical alignment, integrated movement, and injury prevention within contemporary dance practices. Also noting this definition could easily be expanded into a thesis itself.

history. I chose this somatic approach because of its close relationship with embodied dance practices.

- For the final third round, dancers were asked to combine their improvisatory movement while keeping their somatic practices at the forefront of their mind.

I stored these mocap clips, and began creating scenes in Unity to present all of this dance information to the cast of *Hologram* upon returning to UMD. By building an archive of data from 35 different dancers at various places in their careers and training, I was able to place their movement sequences (what I'll call the full length capture of each dancer's motion capture session) side by side utilizing Unity. In our rehearsal process, we called it the "sea of dancers", and it's where I asked the cast of *Hologram* to pull their movement material from, with a few directives:

- First, they were encouraged to pick segments of movement from any of the avatars' movement sequences that spoke to them. This helped them to both A) let go of the need to memorize someone else's improvisation, which can be notoriously difficult, and B) allow them to construct a movement phrase of their own with movements that they felt intuitively connected to (sneakily, this also served as a way to see if they chose moments that seemed more embodied to them, a topic I explore in chapter 2, in furtherance of my question of "are avatars embodied?")
- Second, they were tasked with trying to imagine/retrodict/empathize what the original dancer (whom we captured the movement sequence from) was

feeling, what their technical framework was that shaped how they were moving, maybe even what their body was like. For example, can you tell how tall/long-limbed someone is from how they dance?

- Last, they were asked to be as “faithful” to the movement as they could be, while still fully embodying it in their own unique bodies. Faithful is certainly a term open to different ways of thinking, and because this work was about them as artists self-determining what qualifies, I didn’t give them a specific framework for interpreting it, just to be strict about their own interpretation.

The result of this work became what we called our “archive phrases”, movement phrases we mined for performance, particularly in the first section of *Hologram*, which focuses on the effort of the physical dancing body to meet the digital avatar. Implicit in this endeavour is a central question that bears spelling out: can we feel what the original mover was feeling when they recorded their movement sequence? Can we infer the deeper sequences of muscular activation combined with the particular techniques of the original dancer based on the way the digital body moves? In this practice, we are inherently trying to gain some sense of embodiment with the avatar, which plays along nicely with the other site of exploration; digital identities and their relationship to personal exploration, a process which is facilitated by the Body-Machine Loop.

Chapter 2: <u>What's a Body-Machine, and who loops?</u>

<u>Her Majesty Elephant Queen Cutie of Magic Castle</u>

To explain the Body-Machine Loop, I'd like to start with a story. I'm in my living room and I am cringing while playing *It Takes Two*[9], a video game developed by HazelLight Studios, with my partner. In *It Takes Two*, we are playing two parents in the middle of a fraught divorce and have magically had our consciousnesses trapped inside of two dolls by the tears our daughter shed (in fairy tale fashion) as she wished for our family to be whole again. The conceit of the game is that to become human again, we must do so by taking marriage counseling therapy lessons and use them to solve in-game puzzles and fight enemies, ultimately fixing our relationship by learning to listen, collaborate, and trust each other. I'm cringing because our current objective is to murder our daughter's favorite elephant toy so that she'll cry (so we can steal her tears mind you) and are in the process of ripping the limbs off of this elephant queen (did I mention the elephant is royalty?). Neither of us wants to solve the problem this way, but we can't progress in the game without doing so. My partner turns to me, "I don't think I can do it. Can you finish killing the queen?" I grimace but agree. We mute the TV and eventually, her Majesty Elephant Queen Cutie of Magic Castle falls from the high parapet and dies. Our digital daughter cries, and we consider quitting the game.

[9] HazelLight Studios. *It Takes Two*. Electronic Arts Inc. Nintendo Switch, 2021

It *feels bad*. We *know* that none of these characters are real, and subconsciously understand that none of these events actually transpire, it's just lights displayed on a screen with sound accompanying it, and yet we're upset because we couldn't make a choice, through our game characters, that we felt good about. Digital media theorist Derek Burrill mentions this, saying "player-avatar relationship [*here performer-avatar*] as something less about prosthesis and extension and more about a kind of dual, synchronized (albeit highly mediated) embodiment, where moving (instead of "being") is the central constituting factor in digital and real embodiment."[10] I engage with Burrill's argument that users not only extend their sense of self to some degree into the digital avatars they control, but that the avatars contribute to users' sense of embodied experience from within the digital landscape. This is part of the complex interplay of the Body-Machine Loop, a phenomenon that describes the reciprocal loop between machines, the changes they effect on their users in the form of modifying interactions and disciplining behaviour, and how those changes affect outputs from the use of that technology, discussed below. When viewers watch any of the performers in *Hologram* in their moments of live-stream, and even when the cast themselves are performing live-stream, this interplay exists as a living, dynamic, and changing relationship. I see C Macko's movements in her avatar, and watch as she adjusts, listens to, and partners with her avatar as much as she partners with Emma Young and Vanderlinde near the end of the performance. What differences are there between the partnering Macko does with Young and Vanderlinde vs her

[10] Burrill, Derek A. "'There's a Soldier in All of Us': Choreographing Virtual Recruitment." In Choreographies of 21st Century Wars, edited by Gay Morris and Jens Richard Giersdorf, 63–76. New York: Oxford University Press, 2016.

Miscalibrated avatar? I argue the differences begin and end at corporeality, that the listening, responsiveness, and consideration between Macko and her avatar has a liveness that matches a duet between two corporeal bodies.

Fig 4

Body-Machine Loop Defined

While the term doesn't have a clear and specific authorship, in the fields of cybernetic, digital humanities, gaming, and motion-capture, the Body-Machine Loop generally describes the dynamic process by which individuals and the tools they use mutually shape one another. Theorists such as Norbert Wiener[11] first conceptualized feedback loops in cybernetics, exploring how humans and machines co-regulate one another, while N. Katherine Hayles examined how digital systems reconfigure human embodiment[12]. Susan Kozel has applied this framework to dance and digital performance, illustrating how the body does not

[11] Wiener, Norbert. *Cybernetics: Or Control and Communication in the Animal and the Machine*. Cambridge, MA: MIT Press, 1948.
[12] Hayles, N. Katherine. *How We Became Posthuman: Virtual Bodies in Cybernetics, Literature, and Informatics*. Chicago: University of Chicago Press, 1999.

merely respond to technology but coexists with it, developing a kinesthetic relationship with the machine.[13]

While machines inside the Body-Machine Loop tend to remain static materially, their output and effects change depending on how people use them, while simultaneously requiring users to adapt—physically, cognitively, and even socially—to achieve a particular outcome. An example might be chopsticks: effective use demands precise hand positioning, controlled movements, a refined motor skill set, a particular etiquette. The tool dictates engagement, shaping not only technique but also a unique embodied experience of eating. Similarly, when working with Rokoko, the cast and I learn what movements Rokoko "sees" well, how best to arrange the suit material for accurate readings, how the slipperiness of the hands and feet change where the suit ends and skin begins, even how I need to sit in our rehearsal space while observing motion capture to keep my back posturally healthy. Through this iterative process, users embody the tool's logic by internalizing its structure, limitations, constraints, and importantly how it engages with the world - its framework for action. The Body-Machine Loop is this continual negotiation, where adaptation is both mechanical and embodied. This phenomenon extends beyond physical interaction, shaping perception, identity, and social behaviors. Motion capture, gaming, and digital performance all depend on this loop, wherein the interface (the structures of a tool that a user actually interacts with; think phone screen, keyboard, handle of spoon, etc.) conditions movement, and movement, in turn, informs interaction.

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[13] Kozel, Susan. *Closer: Performance, Technologies, Phenomenology*. Cambridge, MA: MIT Press, 2007.

Considerations of the Body-Machine Loop in digital Avatars

In discussing digital performance, it's important to know a few things, so let's dive deeper; first, what is a digital avatar really? Setting aside the avatars that are fixed images, or animated versions like Apple's Memoji's, a digital avatar is ultimately a collection of mathematical operations that work interdependently with certain movement and image inputs (sets of data) to create and display the image of someone or something in a way that looks convincing to the user of the technology and to the eventual viewer, in this case a body moving and dancing like a person might. Their point is to represent a person. There are three important aspects, the mesh, the rig, and the skin.

Most digital avatars that many different types of creators use typically come preset with a mesh, which is a general representation of the outline of a structure called a game object (which can be anything a creator wants but for my work is human) with no features (think of a dress form in costume design, but digital). This means there's no skin, clothing, body parts, hair, or anything else to give the semblance of a person. These are all things added on by designers/creators later during development and can often be changed.

The rig is a set of connected lines and nodes that act as the skeleton for the mesh to "ride", and are what take the actual movement data and turn it into animation and allow "physics" to happen to the mesh; think of this like a really good stick figure drawing in 3D; X, Y, and Z axes in a coordinate space.

Lastly, the skin, which are all the elements that are part of the appearance of the rig and mesh; clothes, hair, eyes, props, colors, anything that gives the mesh life, including skin itself. Collectively, these are referred to as either materials or textures, I like to think of them as a kind of digital paint to give the game objects a particular look.

The next thing to know is that a great majority of the movements that digital avatars perform are captured from some type of motion capture device recording the action of a human person. These motion capture (mocap) devices make some initial assumptions about the bodies they map motion onto, which were decided in the development phase of the software they run on. For example, they assume the person has five limbs; two legs, two arms, and one head[14]. If they don't, those elements often will still be present. The mocap tool Captury, which uses fixed cameras to observe performers and record motion data (we call this computer vision) has built-in assumptions about both where body parts are and *if* they are there. In Captury, the program expects to see limbs, and will automatically construct those limbs based on available data. The camera looks at the body it sees, and regardless of whether an arm is present, its coding will decide it sees an arm. In one experiment, I hid my arms and tucked my sleeves into my shirt, and Captury still constructed digital arms moving on the avatar's body, the location of which was predicted based on the movement of my torso and shoulders. As long as it *thinks* it sees a body, it believes that body has five limbs. Likewise, Rokoko will show a body moving whether or not the suit is actually being worn by a person, a fact we later exploit during several moments in the show.

[14] For Rokoko, any appendage besides the trunk is considered a limb.

To say the quiet part out loud, digital aesthetics depends a lot on what is automated in these processes. There is a lot the avatar is doing that someone trying to utilize these tools didn't explicitly tell it to do, but that a programmer somewhere in the creation of the software decided was the 'best' way to go. I remind the reader here that Rokoko is a digital technology, and as such uses algorithms to fill in the gaps between data points, which means the software developers at some point decided what that math was, and how much data should be collected at any given point.[15] As I discuss below, the construction of the avatars we use to engage with media and the social, gendered, and racial norms they express often go hand-in-hand, a marked parallel between how our living bodies are trained societally, socially, and physically as a form of discipline and what's assumed of an avatar (discussed further later).

In *Hologram*, we utilize Rokoko's suits and projections of digital avatars performing dance to interrogate the ways motion capture technology encodes both ways of seeing and being seen, and the effect on the decisions our performers make. The Rokoko software transmits what it "sees" from the sensors attached at key points along the suit and presents a kind of digital mannequin, arranged and moving according to what the software "thinks" the physical body is doing and how it's arranged. If what Vanderlinde sees doesn't match the output she expects, she changes her movement, trying to synchronize with the logic of Rokoko in order to gain different outputs. In the *Hologram*'s opening moments, a live-

[15] While I found no readily published discussion by the programmers of Rokoko, we can look to the materiality of the suits and the software to infer some of its values. The suit has 19 wired IMU sensors (17 sensors if Glove-Ready edition), mostly in the arms and legs. The head has one sensor, and the spine 0. This is a fact we notice when we try to create spinal flexion in our mocap recordings. Files are stored as FBX, and a general file size is 13MB, relatively small for the amount of detail the suit could potentially record.

stream projection of Emma Young is projected with her dancing, placing front and center from the first moments that there is a direct relationship between the technology and its user's effects on the projection. In this scene, how well Young has embodied the logic of Rokoko determines how closely her movement and projection match. Young knows Rokoko doesn't respond as well to jerky motion, understands rotations of the limbs should be exaggerated, is guided by the sensation of the headband holding the head's sensor, its weight, and can predict how to temper its tendency to fly off during performance. This logic, among other things, contributes to how she sculpts and shapes her movement through space and what she wants her avatarial form to do.

I emphasize here that the Body-Machine Loop is not simply a matter of tool use; it is a process of reconfiguration, where embodiment, self-perception, and mediated experiences are continuously shaped through interaction. In digital performance, including motion capture and avatar-based movement, this loop becomes particularly pronounced. Where does the performer end and the digital body begin? How does the logic of the machine influence movement, and how does movement feed back into the machine's constraints? The Body-Machine Loop operates not just as a functional process but a relationship that affects the embodied experience of the technology it is mediated by.

A Contingent Phenomenon

Thinking back to the virtual glitch in Rokoko, part of the fascination in this exploration is that I could choose to make Vanderlinde's avatar body and leg from her penché repel each other, similar to a physical body, but I don't *have* to make that choice. By adding colliders, a tool that restricts one game object from sharing a digital location with another, I can program any particular object (everything that is a thing in digital media is called an object, legs and avatars included) to repel another as if it were made from physical stuff, but those are added later, not incorporated from the outset. I, and other users like me, are in control of deciding how, if, or what constraints to give these digital entities and the emulated environment they inhabit. These avatars exist as strictly contingent entities; their limitations in the digital world are choices made by designers and users, not the physics we experience in the real world, elements like gravity, material existence, or the passage of time. In physical performance, I as a performer must often account for things like pain, safety, and potential damage to surroundings when deciding when, where, and how to move. For example, I wouldn't actually attempt to walk with my torso dragging on the ground behind me; gravity, which doesn't affect these digital avatars, would create a huge strain on my body and I'd break in two. These physical realities shape my choices.

By contrast, the digital performer is not subject to such risks. My avatar doesn't experience pain, damage, or wear unless I explicitly program it to. It exists outside the limitations of the physical world, but it's hard not to see the digital body as a performer in its own right. Of course, it isn't really a performer—it's the result of mathematical functions and programming displaying specific graphics in a predetermined way. Because of this, a choreographed sequence can be repeated perfectly, endlessly, as long as the computer's physical state is maintained. Further, the digital performer will never do something it hasn't been told to do—

either by the software it runs on or the programming I input. Its actions are only as precise or erratic as the instructions I give it, reinforcing its existence as a programmable construct rather than an autonomous entity. But when I perform in motion capture, the experience feels like a kind of animist science fiction. What might appear to be a straightforward process—tracking my movements and using that data to animate a 3D digital model in real-time—reveals a web of questions, uncertainties, and complexities. I'm confronted by an ethical consideration with relation between myself and the digital "other", an entity that both extends me and yet remains fundamentally different. Physically, I wonder where my own body ends and the synthetic, digital one begins. And, on a more philosophical level, questions about the very nature of this exchange are inevitable: what kind of existence do these digital entities possess, brought to life through my movements? And what, ultimately, is my relationship to them?

An Embodied Phenomenon

What does embodiment mean in the context of this thesis? Throughout my dance training and career, I have encountered a persistent emphasis, from teachers, peers, makers in the field, among others, on "embodied" movement—embodied performance, embodied technique, embodied experiences. Yet, I find myself questioning: Is it possible to dance without being embodied? Are we emphasizing something that is inherently present, or are we calling attention to a process that requires deliberate articulation? Do we invoke embodiment as a means of making something explicit—of living it in a particular way?

These questions become even more complicated when considering digital performance. What does it mean to embody another performer's digital traces? When a digital avatar replicates a dancer's movement with mathematical precision, does it share in the performer's embodiment, or does it remain something else — a representation rather than a lived experience? The tension between the precision of motion capture and the intangible qualities of embodied experience raises fundamental questions about presence, agency, and the nature of performance in digital spaces. For the preliminary research that created the archival recordings of the 35 dancers, I encouraged those dancers to try and clearly articulate to themselves the essences of the movements they did through their movement, encouraging a somatically based approach to creating archival footage. Later, when the cast of this thesis analyzed those archives, we noted that the translation of movement depends on what the digital body seems to be "interested" in: if the digital body looked masculine, the movements seemed masculine; if the digital body was large and imposing, the movements therefore also took on that affectation. What is perhaps obvious but deserves writing plainly is that we thus cannot separate the movement from the one we perceive performing that movement. This pushes me, somewhat kicking and screaming, to think that embodiment is not something that *is* in some objective sense (either a dancer is embodied in their movement or not), but that some observer decides is.

In other words, in order for the cast and me to connect with the digitized movements of the original dancers, we recognized that we had to see and engage with the digital bodies that were representing and re-presenting the digital analog to that movement as bodies in of themselves, and utilize the kinesthetic empathy (a term for the phenomena of looking at someone moving and imagining what it must be to move in that way ourselves) we would with any performer IRL.

What we bring with us

If I'm playing a game or representing movement in a digital landscape, it provides an opportunity to think about not only what I wish I could do but *who* I could be. In choreographer Marguerite Hemmings and new media artist LaJuné McMillian's virtual reality film *ANTIDOTE*, viewers are invited into a landscape free from the history of violence and oppression enacted on women and POC[16]. Before they engage in this constructed digital world, viewers are asked to agree to a series of agreements: to leave behind their personal connections to patriarchy, capitalism, racism, and other aspects and histories of the physical world so that their experience and contribution to *ANTIDOTE* remain untainted by them. I invoke their work not only for the acknowledgment that when viewers engage with digital medias and enter digital realms, they also agree to some extent to the conceits embedded in those works[17], but also that artists/creators are offering an embodied experience mediated as much by the medium - the screen, phone, projection, etc. - as by the *implicit agreement* made about what role our imagination will play in the coming works. Hemmings and McMillians are making explicit and clear that I am part of the Body-Machine Loop, the reciprocal

[16] Hemmings, Marguerite & McMillan, Lajune. ANTIDOTE, antidote.space, Dec 11th , 2020
[17] This is a phenomenon that many readers will be familiar with when watching many art forms. When we watch an Avengers movie, we're asked to agree to the logic of super powered individuals in a semi-similar universe to ours. In digital landscapes, there is an implicit ask that viewers agree to similar logics; that there is a world in which Super Mario jumps around, or even that the images we see *are* in some sense what they represent. While this isn't a new phenomenon, digital media and motion capture provide a level of interactivity not possible before.

feedback process between a person and the machinic, when I step into their work, just as the performers of *Hologram* are. Russell speaks to this, saying:

> *IRL [In Real Life] falters in its skewed assumption that constructions of online identities are latent, closeted, and fantasy-oriented (e.g., not real) rather than explicit, bristling with potential, and very capable of "living on" away from the space of cyberspace. Instead, AFK [Away From Keyboard] as a term works toward undermining the fetishization of "real life," helping us to see that because realities in the digital are echoed offline, and vice versa, our gestures, explorations, actions online can inform and even deepen our offline, or AFK, existence.*[18]

To harken back to Hemmings and McMillan's *ANTIDOTE*, even though the landscape the users experience is digital, they are asked to breathe, move, and listen to their physical bodies while engaging with the work. Russell taps into this same feeling, that the digital and the analog don't divide cleanly, that there is a reciprocal relationship with digital experience and IRL/AFK. I focus primarily on how the Body-Machine Loop extends the sense of self to an active and embodied digital avatar, and that by doing so, individuals also expand, adjust, experiment, and question their embodied sense of self.

<u>**Playing with Identity and Norms**</u>

Likewise, in "Gaming the System,"[19] Technologist and Ethnologist Kiri Miller discusses the way game players can use a choice of premade characters to explore both different types of gendered movement and different gendered performances in the game *Dance Central*. *Dance Central* was a launch title for the

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[18] Russell, Legacy. *Glitch Feminism*: *A Manifesto*. London, Verso. 2020

[19] Miller, Kiri. "Gaming the System: Gender Performance in Dance Central." New Media & Society 17, no. 6 (2015): 939–957.

Xbox Kinect, the motion-sensing camera peripheral released in 2010, in which a player controls the movements of their game characters by moving their own body and performing choreographies to a wide array of songs, such that the game characters appear to move the same way the user does. Their movement is evaluated by computer vision and is scored for "accuracy" to the moves prompted on-screen.[20] Dance moves have names that often allude to gender, such as the Frat Step, Diva, Eyeliner, Bromance, Muscle Man, Booty Pop, and Pretty Face, and popular dance genres transmit and reinforce established norms for moving one's body in ways considered appropriate to one's identity traits, including gender, sexuality, race, age, and class. The range of available characters lets players treat race and gender as separable variables, and encourages experiments with various combinations of intersectionality: how does a Frat Step or Booty Pop look on a Latinx adult man's body versus an African American young girl's body? How do these moves feel in one's own body when dancing along with different screen bodies?

Here, dance scholar Susan Foster would remind us that all dance repertoires discipline bodies, and "choreography presents a structuring of deep and enduring cultural values that replicates similar sets of values elaborated in other cultural practices."[21] In other words, the performance of gender in game represents certain social archetypes of gendered identity, encoded as dance and enforced through the play of the game: feminine characters are the default for "feminine choreography", for which the dance move names very often perform

[20] Importantly here, Dance Central does not actually show an avatar of the player, nor does their movement change the performing avatar's onscreen body. It simply glows red where the "problem area" is.
[21] Foster, Susan Leigh. Choreographing Empathy: Kinesthesia in Performance. New York: Routledge, 2011.

sexuality, with names like “caress front”, “lapdance”, or “booty pop” and likewise for masculine characters. I, and Miller, suggest Dance Central’s portrayals of gendered performance are simply another method of codifying essential gender qualities, as the more gendered choreographies have a default character that aligns with social ideas of what that gender should perform (female defaults for feminine choreography and male defaults for masculine choreography). Despite the emphasis for experimentation and play in the game, Miller writes,

> *In Dance Central’s design and players’ performances, one can see the residue of strategic choices concerning representation as distinct from the bringing to liveness of those choices. And in this distinctiveness, the contrasting functions of choreography and performance are apparent: dance making theorizes physicality, whereas dancing presents that theory of physicality.*[22]

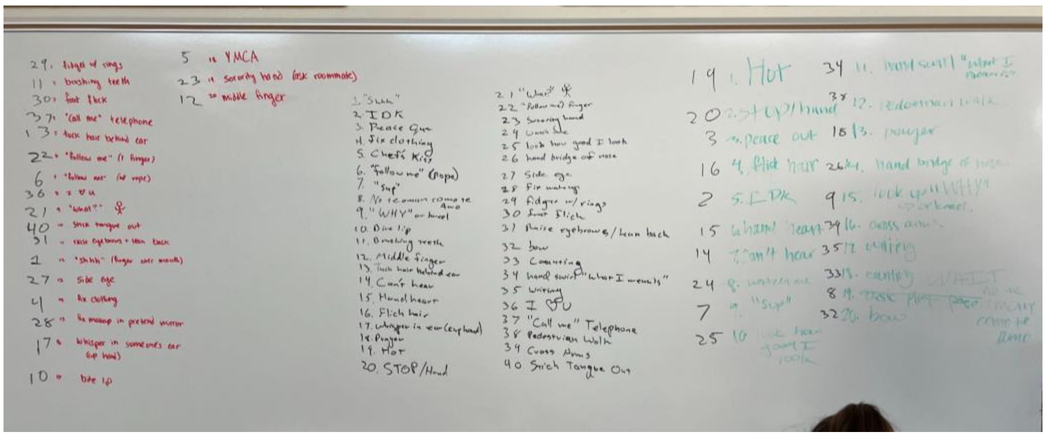
I wanted to connect the questions Miller engages with as related to the work we explore in *Hologram*. Is there space for gender experimentation within this performance on digital identity? I created and downloaded a wide variety of avatars, and then used them to present the archive of movement sequences I created in pre-rehearsal research. I had the cast try on a wide swath of the available movement material, performed by a wide diversity of characters with different presentations of identity. The original performers of the movement sequences were male-identifying, female-identifying, gender non-conforming, from a wide set of backgrounds and cultures, and the cast was encouraged to try and understand the essence of the original mover (discussed earlier). Additionally, in the earlier moments of the rehearsal process, the cast was

[22] Miller, Kiri. 2015

encouraged to pick different premade avatars that they could set as their stand-in during their Rokoko movement recordings, essentially getting to try on different avatars during the rehearsal process. Doing so opened up opportunities for the cast to consider not only the pure choreography of the avatars - tendus, plies, turns, jumps, the mechanics of what the digital body does - but also the character of the avatar that movement is embodied by.

I watched the cast embodying the movements with intense fervor and deep curiosity, constructing not quite the original performer's essence, but something new and meaningful. Exploring gender identity was eventually phased out, but the focus on distilling and amplifying character, physicality, and liveness of the archival material opened up new ideas for expanding, distilling, and refining essences from other movement sources. Macko, for example, took a section of sequence in which an avatar lowered itself to the ground in a push-up position while part of the single hand touching the floor was occluded (blocked from view because it went “through” another material). This occlusion gave the impression that the descending push was done on the avatar's fist, and so Macko added to her archive phrase a one-armed descent on her fist, which was not only impressive but also brought a liveness to the experience of the avatar itself.

In *Hologram*, we explored this idea of embodying the digital liveness in several ways. One such method was the development of gestures duets. Pairs Young/ Zalalutdinov and Vanderlinde/ Macko each worked together to generate a collection of everyday gestures that they observe or know in their lives. I then tasked them to pick an essence of that gesture they could exaggerate enough that the movement became a character of its own, requiring its own embodied sense of identity to perform (I believe the precise wording was “if shushing someone was a person, what would their cartoon character be like?”); a flippant hand toss signifying “How could I forget?” or rubbing the hands down the cheeks of the face for “I’m so exhausted” becoming both more exaggerated and precise demanded a totality of embodiment and imagining of character, for example.



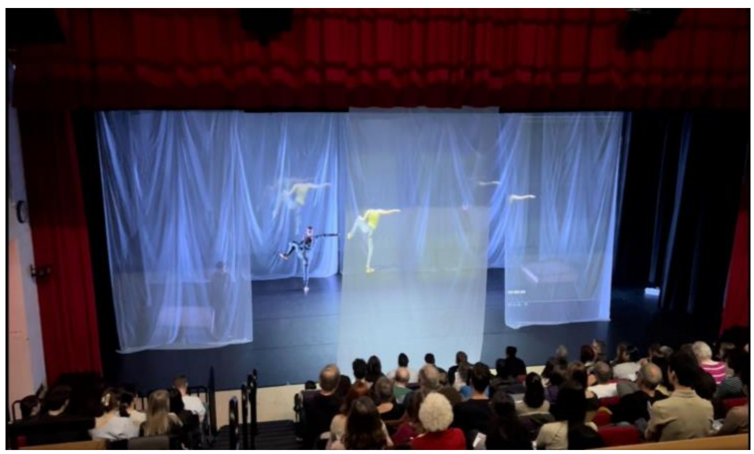
Picture by the author fig 5

I had an expectation that the cast would self-select to overperform gestures that may have had a gendered implication, such as frat flick or sorority hand, but the cast all chose to embody the sensation of the gesture as a thing in itself, embodying the action and their imagination for *why* they would perform the gesture, rather than who they would be. These gesture duets repeat throughout the performance, each time a cascading wash of decontextualized gestures. I wanted these gesture duets to embody the freneticism of digital media (particularly social media), and the punctuated clarity that digital content distills into singular memetic ideas curated to be instantly absorbed. The two resulting duets felt like viral dance trends perhaps seen on TikTok or Instagram.

CHAPTER 3: *HOLOGRAM*

THE CONCERT

The performance space is arranged proscenium style, and in front of the main curtain hangs an 20' x 9' sheet of light blue voile, a soft, sheer cotton fabric that the scenic designers and I sourced as a material to project onto in order to invoke the idea of hologram, something illuminated that seems to have depth and volume but lacks both. Behind the main curtain, which begins shut, there are six more hanging voile, two hanging downstage right and downstage left, and four in a row towards the back of the stage (See below).



Picture by the author fig 6

Picture by the author fig 7

The voile was attached to the catwalks with magnets in order to allow them to be pulled down without damaging the material or requiring a lengthy reset period for production crew. Throughout the performance, images are projected onto the hanging voile, and at different intervals, the voile is pulled down by the performers, revealing more of the performance space for both the viewer's eye and the performers to move in following a general motif of the work; moving from covered to exposed. The goal of the hanging voile was to emulate an illuminated screen and to evoke a tension between true spatial depth and artificially implied depth.

The costumes were designed by UMD Costume designer Johnna Presby, and in our collaboration we wanted to emphasize digital chic, simplicity, and hidden mess. The design had the added complication that the Rokoko suits had technology embedded that needed to stay safe, and the suits themselves needed to be restored after the concert ended. As a result, she layered a set of athletic clothes underneath a grey leotard, which prevented sweat from reaching the outside Rokoko suit, which had sewn on appliques to enhance the technology vibe. See figures below.

Photo by Taneen Momeni fig 8

Photo by Taneen Momeni fig 9

Opening: Livestream of different kinds

In the opening section of *Hologram*, we start with the live stream projection of performer Emma Young, who performs a solo behind a closed mainstage curtain at the beginning of the work with the live-stream capture projected onto the hanging voile at the center of the curtain. Watching a projected, digital body performing dance in a void, liminal space is meant to suggest to the audience that the material is pre-recorded, as most moving digital images are. I made the decision to initially hide Young's performance as a way to set the audience into a familiar setting, sitting and observing a screen that delivers to them digital content that they can remove themselves from, and in doing so give myself the opportunity to rudely interrupt the sense of detached observer, an observer that is in some sense insulated from the content they observe, with the immediacy of active witnessing in the creation of a live-stream duet. The reveal of Young as the source of the projection introduces the audience to their first experience with the live-stream element of the concert, and is also the first explicit moment of driving the relationship between the digital bodies and the physical bodies that are often mined for motion data. The opening live stream of performer Young ends with her gently beckoning C Macko and the rest of the cast to come onstage and emulate her solo performance. Emma Vanderlinde and Julie Zalalutdinov join Macko in an improvisational score centered on what they had just witnessed Young perform, both matching and embellishing on the movements she made, before Young goes to the center front voile curtain and pulls it down. Throughout this section, lighting designer Hannah Kelly and I decided to employ water hues and tones as a subtle method of prefacing the end of the concert.

In this moment, I always think back to our rehearsal process in some of our earliest experimentations with the voile, and how after some exploration with both projecting on and manipulating the material, the cast noted that the longer the material acts as a screen - a material that invokes ideas of static, fixed, rigid form - the more impactful the moment when its soft, fluid, folding nature is emphasized. This first moment of pulling down the voile curtain is always satisfying to me, as its transformation from a static screen to dynamic material mirrors the tension of digital technologies as either agent of discipline, setting the framework for how individuals may access and interact with the world, or site of access, malleable to the needs of the user, light, and contingent.

Liminal Duet: Macko and Vanderlinde

In a brief interlude, the cast move in front of the downstage left voile panel, and perform a short line dance sequence, a sequence that repeats quite often throughout *Hologram*, gradually evolving from unemphatic and mechanical to something more live and human. Young and Zalalutdinov interrupt this with the first of their gestures duets, a string of disconnected everyday gestures pulled out of context in the style of a social media dance trend, ending with two middle fingers raised at each other. Following this section is a duet between Macko and Vanderlinde, who both move to stand on boxes stage right and left, performing a synchronized gesture duet evocative of a string of emojis flooding from a message board. They alternate gesturing at each other and dancing in a constrained environment. They both stay constrained, unable to leave the confines of the hanging voile that frame them, until they finally acknowledge and see each other across the expanse of the stage. They both pull down their voile panels (downstage right and left), move to each other and perform an improvised duet in which they are constantly leaning on each other, carrying and lifting each other until they finally shake and collapse to the floor.

Fig 10

What this section meant, what it was about for me and for the cast, was a bit of a mystery to me during the rehearsal and production of the work; this was a time, as an artist, when I had to trust my instincts that it belonged. Now that the work has been performed, I understand that this section is about the liminal space between those who engage with each other through digital mediation. The choice to walk across the stage was always there, but the decision to remove the “screen” setup and engage physically with their partner was a necessary predicate to occupy the vast availability of space they otherwise were restricted by.

Zalaludtinov and Young return to stage and drag Macko and Vanderlinde to the edges of the performance space, changing the nature of Macko and Vanderlinde’s active bodies to passive material, evoking a parallel between the materiality of the body and disposability of digitally generated content. Throughout the work, there is a soft, slowly unfolding motif that emphasizes the resource cost to action, engagement, and use of digital media, and the impact on the human body is one of such cost (discussed further in Ch. 4). Zalalutdinov and Young then clean the floor with the voile just pulled down and cover both Macko and Vanderlinde.

Pressure Box: Young and Zalalutdinov

The duet of Young and Zalalutdinov that follows happens against a backdrop of digital avatars performing the same material as they do. This choreography is physically demanding and repetitive, in order to emphasize the difference between the real effort of action of physical bodies and the infinitely repeatable actions of the digital avatar.

They repeat this duet twice, trying to take information from the projected scene, searching to gain something from it. When they ultimately struggle to match the pace, ease, repeatability of the avatars, they are demonstrating the tension of what digital researcher in psycholinguistics and literacy, J.P. Gee, says:

> *We create avatars to leave our bodies behind, yet take the body with us in the form of codes and assumptions about what does and does not constitute a legitimate interface with reality – virtual or otherwise... the worlds we create – and the avatarial bodies through which we experience them – seem destined to mirror not our wholeness, but our lack of it.*[23]

In his work, Gee describes the phenomenon of "leaving the body behind" as reflecting an existential feeling of inadequacy within our physical selves. This leads us to fashion avatars through which we engage with a realm that seems to surpass the imperfections of our biological existence. However, the digital world is as real as the analog. Additionally, the allure of a digital world, unconstrained from the limitations of the physical within digital media, is not as true as I might

[23] Gee, J. P. "What video games have to teach us about learning and literacy". New York: Palgrave Macmillan (2004).

like. That allure ignores the fact that the digital must be engaged with by me, by a body, full of needs and demands and suffering the passage of time. In games I can fly or use magic; in digital landscapes I can watch my body dance without tiring and without being encumbered by gravity, walls, or physics, but Zalalutdinov and Young cannot opt out of these constraints. Creating this duet between Young and Zalalutdinov is how I explored the pressures of reality, both social pressures of digital representation and physical pressures of trying to match our digital counterparts.

Quadrants

In our rehearsal process, the cast and I created a section we called "Quadrants" where I projected the same "sea of dancers" scene from our archive of initial research and tasked the dancers with following a random avatar and trying to perform the movements in real time. This section is buoyed by an idea from Derek Burrill, who we heard from earlier.

In Burrill's *There's a Soldier in All of Us,* he discusses the U.S. Military's online game series, *America's Army*, produced by the US Army to give civilian youths an inside look of what a soldier's experience is like. Through providing realistic choreographies of the body, this game engages in such realism, as well as detailed and sometimes "boring" choreography (including the training sequence players engage with at the beginning of the story) that "…it appears to train and reward masculine behaviors often equated with nationalism, power, and control."[24]

[24] Burrill, Derek, *There's a soldier in all of us,* 2011

The player is effectively engaging with the choreography of the "Soldier". In this, Burrill looks at something I also see; if whether avatars respond well or poorly (succeed or fail in their respective tasks) reinforces how players engage with the medium of the game, then it is just as Susan Foster suggests, the choreography of the soldier can discipline the player by the same means.[25] Thinking back to *Dance Central,* players adjust their dance moves to get higher scores, attempting to align their actions to the performing avatar - in *America's Army* players learn to duck, dive, aim, and obey to do well. In this way, the game avatar, which represents all-male empowerment and control, does something somehow unexpected, in that it actually *objectifies* the player (makes them an *object* that a *subject* acts upon), shifting them from an active agent controlling the action to a passive subject being shaped by it. This inversion aligns with Burrill's reading of Slavoj Žižek, who states:

> *[...]the fundamental mode of the object's passivity, of its passive presence, is that which moves, annoys, disturbs, traumatizes us (subjects): at its most radical the object is that which objects, that which disturbs the smooth running of things. Thus the paradox is that the roles are reversed (in terms of the standard notion of the active subject working on the passive object): the subject is defined by a fundamental passivity, and it is the object from which movement comes.*[26]

Žižek reframes passivity not as mere stillness but as a form of dependence—to be passive means to be shaped by an external force, while to be active means to impose change. Here, both Žižek and Burrill reveal a contradiction: the avatar, which appears to be an inert, controlled object, is actually an active force that

[25] Foster Susan Leigh (1998) Choreographies of gender. Signs 24(1): 1–33.
[26] Žižek, Slavoj. *The Parallax View.* Cambridge, MA: MIT Press, 2006.

conditions and transforms the player. To put it plainly, when taken to its limit, the avatar shapes the user the more they are invested in the outcome of the work I create. I immediately wanted to explore this idea, that the technology not only gives feedback, but actually molds users in an active way.

Fig 12

As the section *Quadrants* begins, the cast moves behind the upstage length of voile, and the archival Sea of Dancers (Ch. 1) is projected along its length. The cast was given the directive of trying to follow the actions of the avatars as perfectly as possible, a task that is incredibly difficult given the avatars spin around, glitch through themselves, sometimes float through space, often move in ways that are either too fast, or too impossible to intuit. From a performance lens, Burrill argues, the user internalizes the structure of the digital through:

> "repeated and absorbed maneuvers in the game (i.e., the choreography) that flow back to the player and his or her body so that the player becomes subjected to the point of objectification, a ready-made soldier, complete with foreknowledge of military strategy and tactics (and the accompanying choreography of the soldier in battle)".[27]

[27] Burrill, Derek, *There's a soldier in all of us,* 2011

When I read this description of Burrill's, I was struck by the similarity of these methods to studio practice in dance. This dynamic mirrors how dancers are trained—socially, physically, and posturally—through repetition and reinforcement. Just as digital avatars in war games function as both tools and enforcers of training, dance pedagogies discipline bodies, guiding students toward particular movements, reactions, and behaviors, and can have similar levels of strictness in adherence to discipline. In digital performance, the avatar is not merely an extension of the dancer; rather, it imposes a structure that the performers must adapt to, reinforcing a disciplinary loop not dissimilar to formal dance training.

Fig 13

What I was interested in here was not for the dancers to achieve success in trying to perfectly match the movements of the avatars. I cared much more about the struggle of the seeming impossibility of the task; not only are there many distinct movement phrases for the dancers to watch, each movement phrase is a different length, so if the avatar a cast member was watching stops moving, they must immediately switch to an actively dancing avatar as quickly as possible, dropping into a new movement with a new physicality. In addition to this, each cast member has their own voile panel to look at initially. As time goes on, the panels go out one by one. When a panel goes dark, they must switch to the next panel over and share performance space with their next cast member, eventually forcing all four performers to occupy the same voile panel and 9x9 dancing area. Additionally, the number of dancing avatars slowly reduces, until all four cast members have shifted their attention and dancing (what we might call a reverse live-stream) from a wide diversity of performing avatars to the same avatar, resulting in a unification of action. Even the moment the final avatar stops moving is performed by the cast, staying in an eerie stillness until Macko, Young, and Zalaludtinov leave Vanderlinde behind and walk off.[28]

Fig 14

[28] I should add here that the creation of this section originally had one large image (roughly 25'x25') displayed on the back wall of our rehearsal space, which allowed both viewers, myself and guests who watched some rehearsals, and the cast members to focus on a single image. In the final presentation of this section, because of the way the theater projectors needed to be focused, there was a splitting of that single image into several smaller images, which changed the impact.

Uno: Duo: Trio

Vanderlinde's miscalibration solo follows Quadrants and is the first time the tone of the work switches the relationship of the technology from the cast being shaped by it, to having the technology work for them and treating the technology as a partner. Vanderlinde comes downstage of the voile curtains, ripping one down along the way, and tosses it into the center of the space. Her cast members come out one by one, offering a water bottle, the smart sensor Rokoko gloves (which we eventually cut for time due to the logistical difficulty putting them on with sweaty hands), and we project Rokoko suite onto the voile, showing for the first time the User Interface (UI, the digital tools the user interacts with to make a tool do work) of Rokoko.

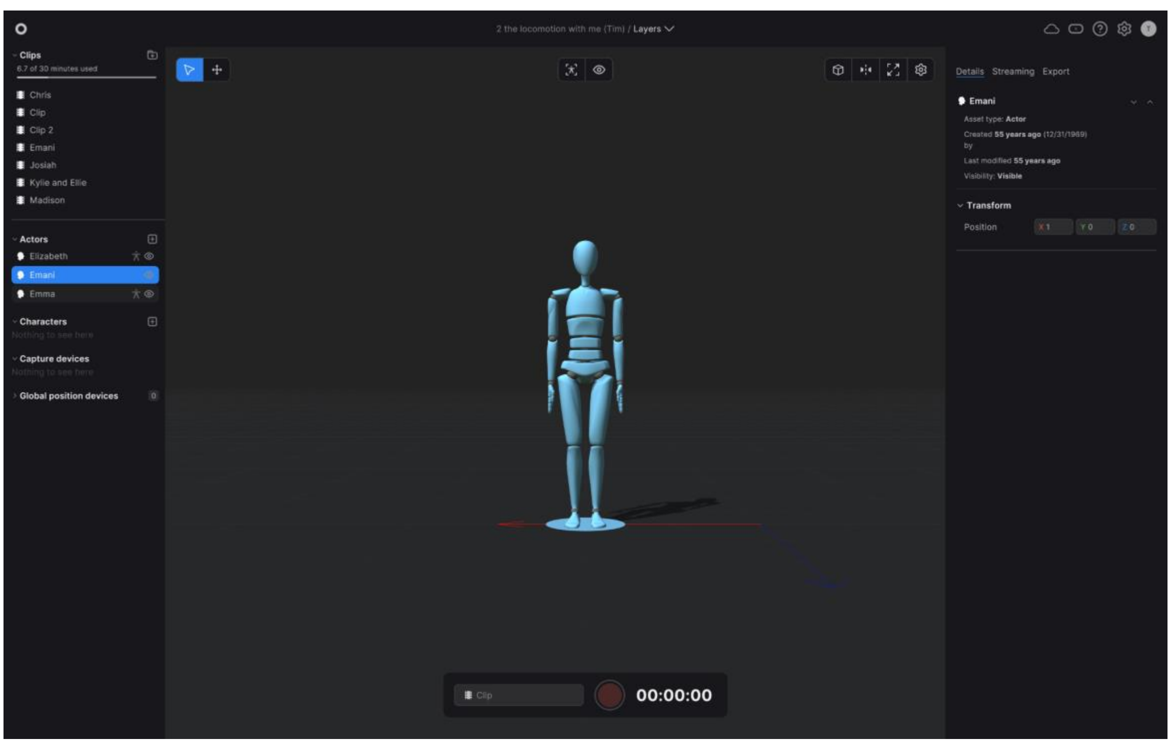


Fig 15

Both the showing of the UI and Vanderlinde drinking from a water bottle breaks a somewhat unspoken rule of performances; don't show the audience how the "magic happens". This plays out in many ways; productions almost universally hide the lights that illuminate the stage, stagehands wear all black to remain hidden while doing incredible, important work backstage, performers are generally trained to hide their fatigue, signs of struggle, moments of confusion. What I wanted to do, both in this solo and throughout the piece was to expose as much of how both the technology and the materiality of the production itself happens.

Vanderlinde acknowledges the projection and calibrates normally (in standard calibration pose), checks that her avatar is responding well, and then folds over and recalibrates in this forward fold. This creates the nightmare avatarial body discussed in Chapter. 1 and she improvises movements here, exploring how she can push the limits of what both she and the avatar can do. The reaction here is predictable. By this point, I noticed that the audience becomes acquainted enough with the avatarial bodies to impart some level of embodiment to them, and to see it bend and fold in ways that would break a person evokes a fair amount of discomfort from viewers, particularly when Vanderlinde goes into a backbend, making the avatar essentially impale itself from underneath.

Fig 16

Here, I sought to evoke the tension between what dancer, philosopher, and digital technology performance theorist Susan Kozel discusses, saying

> *When I encounter my digital self I discover that it is not simply me. The relation between myself and the figure I animate is as chiasmic as the seeing-seen, the touching-touched. It is me, because it is animated by my movement, but it is also other because it is separated from me by the thickness of the space between us and because it moves around and looks back at me—I am the one wearing the motion capture markers, the animation is projected onto a surface next to me, we are the same but we are different in space and in dynamic form. The figure with which I perform is always at the same time both my own body and another body;*[29]

Kozel here speaks to the same tension I feel and want to expose in this work; where do I stop and the machine begin? When does my identity, the nature of me, go from being an imprint on the world I interact with and encompass that part of the world, however small, into my sense of identity? These questions drove Vanderlinde's solo/duet - are audiences sympathizing with Vanderlinde or her avatar? Because Vanderlinde's avatar no longer directly reflects what her physical body does, but is still clearly a product of her movement, does this new

[29] Kozel, Susan *Closer: Performance, Technologies, Phenomenology*. Cambridge, MA: MIT Press, 2007.

relationship encourage viewers to consider the avatar as a part of her, reinforcing the extension of the self to the digital, or separate, breaking whatever relationship they may have built up until then between the physical body and its avatar?

Fig 17

We continue these questions with Macko's solo/trio, finding a similar miscalibration that this time plays with alignment of body in relationship to gravity, structure, and the tension of a physical vs contingent body by calibrating her leaning forward, supported by Young and Vanderlinde. The resulting avatarial pose leans back, unencumbered by gravity and as if it were held up from underneath. One of the amazing revelations about this miscalibration is that, when Macko and I were experimenting with this pose in rehearsals, the avatar, rather than rotating about its axis while leaning back, spirals around the location of the feet, meaning the body spins as if in water approaching a drain. As Macko performs the miscalibrated solo, aided by the bodies of Young and Vanderlinde lifting and supporting her, we can see her avatar swirling around the digital landscape it’s in, greatly amplifying the effect of the lifts and turns of the performance. Whether this is a solo, trio, or quartet will depend on the viewer's personal philosophy. I see it as a merging of the four, ebbing in and out of unification and separation. As Macko’s solo/trio/quartet ends, she lays on the floor as Young and Vanderlinde unzip the closed covers on the suits that hide and house the sensors, wires, and some vibrant mesh material added and designed by Costume designer Johnna Presby, something I see as akin to an emerging, breathing entity, an acknowledging of the interconnected nature of the technology to both the self and to the group.

Subordinating the Suit

Macko, Young, and Vanderlinde leave the stage, and Zalalutdinov enters. She has removed the Rokoko suit and the grey leotard underneath and is in colorful sportswear. Her Rokoko suit is attached to her body via the straps that tighten and secure along the legs and arms, with the headband affixed as normal. The suit hangs off of her, effectively dead weight, but still calibrated to her movement. Throughout the work, we have generally been shifting from intended use of the technology to glitch and edge case, testing the limits of both intended use and artistic representation. For this moment with Zalalutdinov, I wanted to show the audience that the suit and its relationship to the wearer is fluid, that representing movement via a digital body can be both constraining and revelatory. As Zalalutdinov dances, the avatar also dances, but the suit swinging from her body also creates ephemeral traces of her movement, drifting, swinging, pulling her with the energy and momentum of the movement she imparts into it. The suit dances with her, on her, along with her.

Fig 18

Zalalutdinov dances from stage left to right in a structured improvisation based on prompts like gravity, sensation, time, contact, and other guiding words that entail a physical body. At this point in the work, the cast has mostly removed their Rokoko suits, pulled down a majority of the voile panels, and have pulled open most of the wings (hanging curtains that obscure the stands the lighting fixtures hang from). This is the audience's final time seeing a Rokoko suit move, and also the first time seeing the body underneath it move at the same time, as before the majority of the body is hidden in the suit, only face, hands, and feet showing. After cycling through for a fifth time, Zalalutdinov raises her arms forward, either surrendering or accepting, as the rest of the cast come out and detach the suit from her body. While this happens, we get our first look at the way the avatar crumples when the suit is taken off, the digital body folding in physically impossible ways, in a way that is either horrifying or amusing I'm not sure, before Zalalutdinov picks up the suit and slowly waltzes away with it as partner.

During Zalalutdinov’s solo, she dances with the Rokoko suit dangling off her body, and the projection of her dancing is still a reflection of the dance she does, though it degrades. When the suit is removed, I had the livestream continue so the audience could watch the avatar comport to the data it’s being sent, turning into a crumpled figure whom Zalalutdinov embraces despite an intentionally contentious tableau. During Vanderlinde’s solo, there is a similar phenomenon, where the aesthetic of the backbend glitch creates the framework for the type of movement she will employ, thus structuring her framework for action in the solo. When we employ glitch, either intentionally or not, that glitch changes the rules, adjusts the bounds of what I can create in the moment. Do these moments represent the avatar as an agent of control, where Zalalutdinov's physical body is subordinated to the demands of the digital system, her movements constrained by the external logic of motion capture?

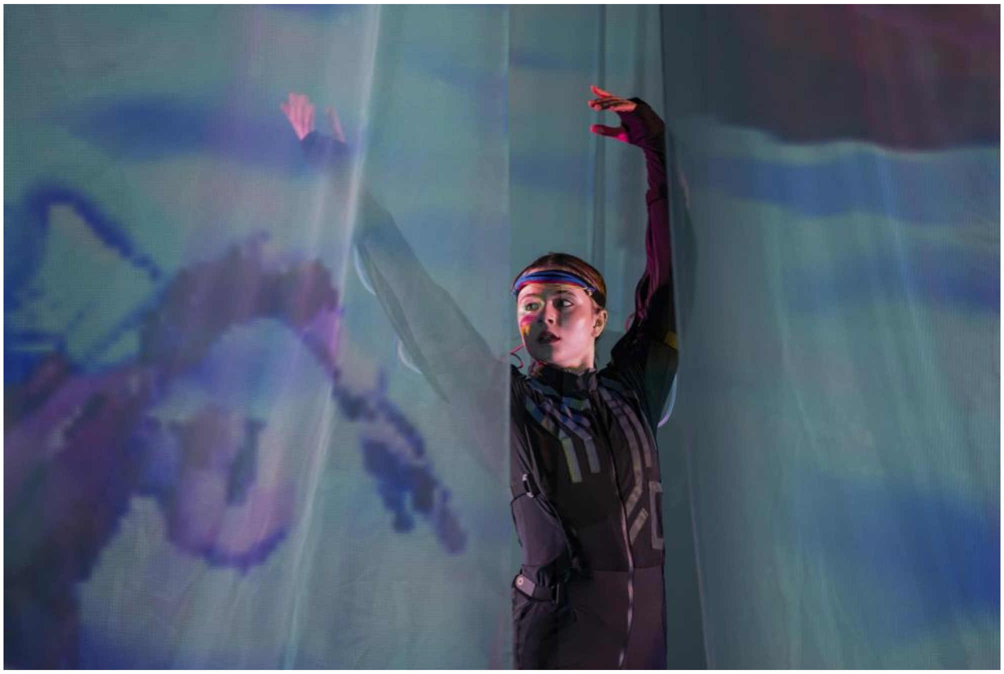


Fig 19

As Burrill notes, writing about *America's Army,* "the effect of whether avatars respond well or poorly reinforces how players engage with the medium of the game"[30], speaking to the power of the Body-Machine Loop to condition behaviour and constrain action, discussed more fully elsewhere in this writing. Russell's framework offers an alternative reading. If Burrill and Žižek see digital mediation as an inversion that subordinates the user to the technology, Russell suggests that the digital realm is inherently glitchy, unstable, and resistant to containment. As Russell writes, "bodies in this era of visual culture have no single destination but rather take on a distributed nature, fluidly occupying many beings, many places, all at once" (Russell 2020, 89). The disjunction between Zalalutdinov and the suit—where the projection of movement degrades and

[30] Burrill, *America's Army*, 86

eventually moves independently—introduces rupture and fragmentation rather than coherence and control. In Russell's framing, digital embodiment does not merely impose discipline but disperses identity, producing a subjectivity that exists across multiple, disjointed sites of mediation. The digital body is not a single, obedient entity but a fractured one, shifting between different states, unable to be fully fixed or stabilized.

A Celebration in Water

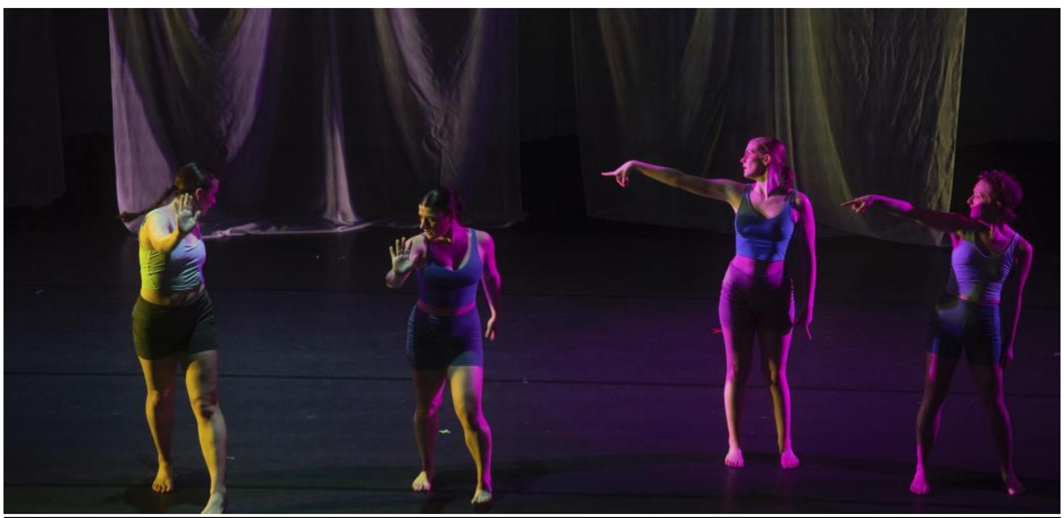


Fig 20

The final moment of this work is a celebration of the body and its expressive possibilities, serving as a kinesthetic reminder that the digital realm exists to expand, enhance, encapsulate, emulate, and celebrate the human body—both in service of it and in reference to it. The cast begins by performing their gesture duets, progressing downstage, relishing in the absence of a technology of surveillance that they have been working with for the entire show prior.

Fig 21

As they finish, the cast cycles through the line dance they have been performing, each time through adding more to the sequence, and this time the gesture duets and line dance are performed, there is a liveness and vibrancy that was absent earlier. As the cast finishes, they pull down the remaining voile, open the remaining wings, and return to center stage as Zalalutdinov and Vanderlinde hold up a panel of voile horizontally. Macko and Young dance behind it, intermittently pushing and brushing the material causing the light from sides to illuminate it in constantly oscillating hues of Cyan, Magenta, and Yellow, colors that combine to create other colors onstage, referencing once more that while the digital is beautiful, it is a complex mix of illusion, material, and human interaction.

The work ends with almost all the stage lighting turning off, except for six side lights, each shining light into a container of water that bounces light off of its surface to send diffraction patterns (think the waving lights that might be seen in a pool that oscillate with the surface of the water) onto the final hanging voile at the back of the stage.[31] This is our final moment to remind the audience of the essential and hidden components of digital media; light, water, bodies, screens, and the viewer.

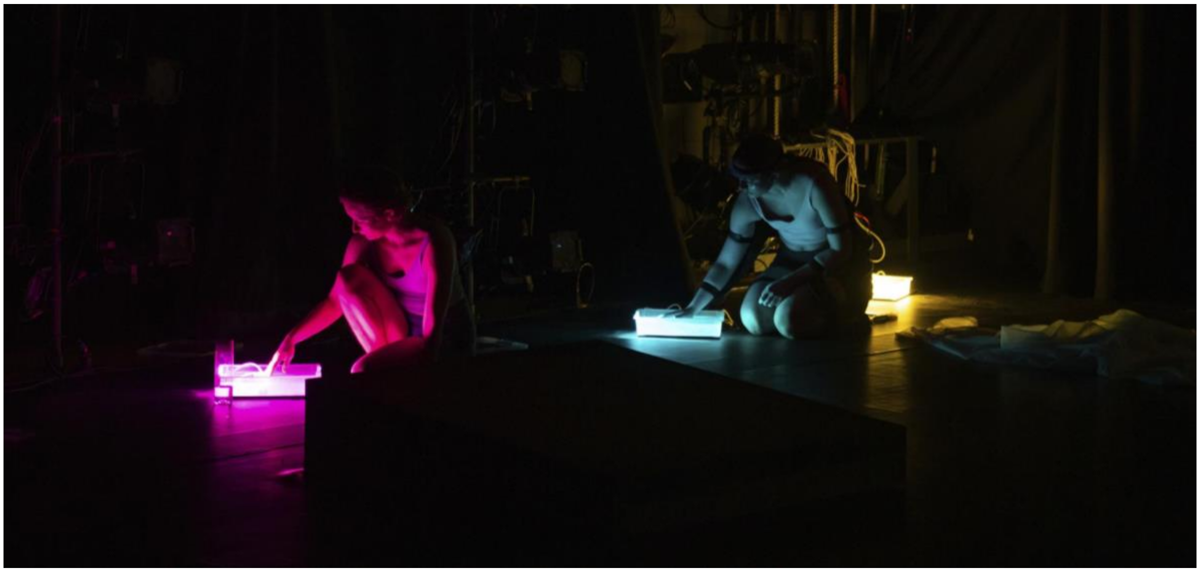


Fig 22

[31] Sadly, this effect had trouble manifesting due to the size of the screen and limitations of how much water we could bring near the lights. Lighting designer Hannah Kelly added a lighting effect to simulate waves, with the side lights supplementing.

Chapter 4: The mess of technology

When glitch is actually awful

After much debate and work, the cast and I have decided our Rokoko suits have a personality. During the technical rehearsal process in the days leading up to the performance of *Hologram*, the work that I, the designers, our cast, and some outside helpers did to ensure the technology worked as intended transformed from the initial "How does the technology work and how can we be strategic about engaging with those parameters to the greatest effect?" to "The suits get fussy if you don't turn them on in their favorite way so be nice to them. Also metal has bad vibes so keep the suits away." Quite often, the suits would lose connectivity to the router, causing live motion capture to fail and the associated effect to fail. For the sake of creating a cohesive performance that survived these risks, we created A/B routes, similar to an *if/else* argument in any general coding language: "If live stream works, perform as rehearsed. Else, do [fill in backup plan here] instead." For performer Emma Vanderlinde, who performs a critical solo (or duet, depending on whether you consider her projected avatar body a performer in their own right), the A route was, "perform a live streamed solo in which your avatar is calibrated differently than your physical body represents", and route B was "Perform an improvisation solo while slowly removing the Rokoko suit and let it swing behind you as you move."

What became clear was that Rokoko was not a part of this show as idle technology like lights or the Marley - a vinyl like flooring that is used as dance floors - but instead was an unreliable performer alongside us. We had check ins with the suits before every show to “see how they were feeling” (meaning doing a test run for any connectivity issues), dark sensor chains (meaning a sensor along the chain had failed for some reason), and drifting (when the data transmitting from the suit to the program quickly degrades due to interference). Ironically, while all our experts assisting us said the odds of true interference was incredibly small, these adjustments were nonetheless recommended anyway because “Rokoko is just fussy”.

The clearest example I experienced of this phenomenon was Rokoko’s absolutely maddening unreliability as a performative tool, and even as a rehearsal tool. During the final technical rehearsals for the concert, Rokoko failed to operate on every occasion for a showing of the work until our opening night, and so I was forced to utilize every possible method to increase its chance for success. For future users who may want to utilize some solutions, several options may be:

- Relocating the router that receives the signal from the suits and sends them to the computer from off stage to the catwalk directly above the stage, antennas pointing down, so the backstage curtain didn’t block the signal.
- Reconfiguring all possible network settings on the receiving computer to only see the signal from the router. Deleting non-relevant networks

may ensure a different network isn't connected to during a moment of low connectivity.

- Performing tests before every show to make sure the suits havn't developed an issue between last use and then.
- Asking the audience to (please) turn off their wifi to decrease the chance of interference.
- Switching out sensors in the suits (that were working perfectly fine 10 minutes ago I swear).
- Writing and implementing a full procedure for production crew to observe before and during the show, including keeping metal away from the suits as much as possible. Things that may be clear to primary users of the technology will not be to others.
- Hardlining the Rokoko router to the theater's ethernet for a direct connection rather than wifi. [32]

Our Fifth Cast Member

In rehearsals, I would often find myself creating choreographic tasks to occupy the cast's time while I try to figure out why a suit has stopped connecting to the software despite the indicator showing there is full connectivity, or rerecording a motion capture clip of a dancer because a sensor stopped working, causing/making/leading the resulting animation clip to effectively lock the limb in

[32] The technically minded reader will notice that many of these fixes shouldn't make any noticeable difference in the technology's performance. Connecting directly to the ethernet should mean wifi interference is impossible. Reconfiguring network settings also shouldn't impact connectivity when a network is selected. Moving the router shouldn't make a difference because of a curtain. And yet these changes made each performance (mostly) a success.

place, and forcing us to diagnose the sensor and then try again (I uttered “let’s power-cycle” - our shorthand for “turn it off and then back on again” - too many times to count). Even when the technology worked well, I often found that our rehearsal tasks were to work not only with, but around, the possibilities of the suits. In advising conversations with Thesis chair Adriane Fang, we realized that the cast and I treated the whole apparatus of Rokoko as our unreliable 5th cast member; often fussy, often amazing, but always forcing us to work by its standards, inflexible and unyielding and ultimately in control of the success of our work.

One of our problems was making sure that both the performers onstage and the tech operators in the booth were coordinated about whether Rokoko maintained connectivity to the suits and whether the suit had been calibrated successfully. Because the connection from the suits to Rokoko could be interrupted at any time, at any of several points of failure, how does the booth let the performer know if the last calibration attempt was actually successful, or if the connection dropped? For us, that meant solving how to communicate to the performers, after a successful calibration, if they should proceed with A or B route. To address this, we created a light communication system from the booth where a light would flash to indicate that the connection was successful at that moment. If the light didn’t come on, the performer (in this case Vanderlinde) would perform their route B, and the media operator would either project the recorded footage of a previous performance, or not project at all. However, for Young, who was first to perform via live stream, we had no option for such a plan due to the mainstage curtain blocking her view of the booth, the last communication would have been a thumbs up from the backstage manager. This solo is both the most crucial and most risky, and made every performance full of anxiety because we wouldn't know if Young's solo would succeed until the show actually began. In fact, the very first time this technology worked as intended was the opening night of the show, where supportive colleagues, booth operators, and I all had a tiny, silent celebration in the moment of its success.

CHAPTER 5: Considerations beyond

Motion Capture: A Medium of Flow, Not Containment

The term motion capture is misleading—it implies that movement, once recorded, is contained like an insect in a jar. But in practice, motion capture is about flow, transformation, and the translation of human movement into a digital medium. It doesn't just preserve motion; it reshapes and reinterprets it. In the gaming industry, an avatar's animation is often a waiting vessel—an empty shell until motion data is applied to breathe life into it. In motion capture performance, the dynamic is different. I see the avatar, animated in real time, possessing an agency distinct from its human performer. As the cast dances, their motion is translated, but the avatar's performance exists as something separate, a product of both embodied movement and digital mediation.

According to Brad deGraf and Emre Yilmaz, pioneers in using motion capture for computer animation, motion capture "combines the qualities of puppetry, live action, stop motion animation, game intelligence and other forms into an entirely new medium."[33] Rather than simply duplicating human motion, motion capture creates a hybrid space where human movement is filtered through digital frameworks, introducing new possibilities and constraints. The dancer and the avatar form a new composite entity, neither wholly human nor entirely artificial, but something in between—a manifestation of the Body-Machine Loop in digital performance.

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[33] deGraf, Brad, and Yilmaz, Emre. "Motion Capture: A New Era." Animation World Magazine 3, no. 11 (February 1999). https://www.awn.com/mag/issue3.11/3.11pages/degrafmotion.php3.

In the moment of separation in her solo, Zalalutdinov's suit is neither fully an extension of nor entirely autonomous; instead, it exists in an intermediary space, both dependent on and detached from the human body. This tension exemplifies the contradictions within digital performance—where the act of motion capture simultaneously enforces control and opens up the possibility for fragmentation, excess, and the refusal of singular embodiment. The suit, like the avatar it animates, becomes an unstable object—one that at times trains and disciplines, and at other times resists and unsettles. From a human-centered perspective, the challenges to corporeality and identity are greater with mocap and wearables: the corporeal, philosophical, social, and spiritual implications are more complex as technologies move increasingly close to our bodies and our personal lives. As legal scholars writing on the intersection of law, technology, and national security, Benjamin Wittes and Jane Chong write,

> *As a descriptive matter, sharp legal divisions between man and machine are turning into something of a contrivance. Look at people on the street, at the degree to which human-machine integrations have fundamentally altered the shape of our daily lives. Even beyond the pacemakers and the occasional robotic prosthetics, we increasingly wear our computers—whether Google Glass or Samsung Galaxy Gear. We strap on devices that record our steps and our heart rates. We take pictures by winking. Even relatively old-school humans are glued to their cell phones, using them not just as communications portals, but also for directions, to spend money, for informational feeds of varying sorts, and as recorders of data seen and heard and formerly—but no longer—memorized… There is, however, another way to think about all of this: what if we were to understand technology itself as increasingly part of our very being?*
>
> *Indeed, do we care so much about whether and how the government accesses our data perhaps because the line between ourselves and the machines that generate the data is getting fuzzier? Perhaps the NSA*

disclosures have struck such a chord with so many people because on a visceral level we know what our law has not yet begun to recognize: that we are already juvenile cyborgs, and fast becoming adolescent cyborgs; we fear that as adult cyborgs, we will get from the state nothing more than the rights of the machine with respect to those areas of our lives that are bound up with the capabilities of the machine.[34]

A Material Materiality

Broadly speaking, one of the focuses of this research was to bring attention to and interrogate the way in which digital technologies rely on these massive physical infrastructures, labor, and environmental extraction, despite general efforts by the electronic and digital media industry evoke a sense of digital weightlessness, ephemerality, almost magic-like in the way it doesn't interfere with your desire to access the fruits of that infrastructure. As early technological theorist Norbert Wiener says in *The Human use of Human Beings*, "Let us remember that the automatic machine [here digital media technologies], whatever we may think of any feelings it may or may not have, is the precise economic equivalent of slave labor. Any labor which competes with slave labor must accept the economic conditions of slave labor."[35] Much of the digital media world relies on ghost work—the uncredited human labor behind AI, gaming, and digital content, including motion capture performers, data labelers, and content moderators, and the natural resources that all digital industry relies on, mostly water - which cools data centers with heatsinks, centers that are often built

[34] Wittes, Benjamin, and Chong, Jane. "Our Cyborg Future: Law and Policy Implications." Brookings Institution, September 2014. https://www.brookings.edu/articles/our-cyborg-future-law-and-policy-implications/.
[35] Wiener, Norbert, The human use of human beings. Boston,: Houghton Mifflin. (1954).

underwater for that purpose, and rare earth metals - where the prices paid do not reflect the costs of excavation, to the people who work these mines, to the damage to the environment that is borne by all people.

When I access Rokoko, plug that data into Unity, and create a performance within it, I'm only able to do so because I am not paying the true cost these actions would require if somewhere along this chain of production - a viable internet infrastructure, mining rare earth metals, creating commercially available low cost computing devices, construction of semiconductor chips, building of software, building on top of existing software, on and on - did not at likely several points replace waged labor with unwaged "free" labor, a privilege built upon layer and layers of socio-economic work, much of which goes uncredited and unwaged. The capacity of digital systems to seemingly endlessly repeat operations with fidelity as many times as a user may like relies on the energy cost that drives those operations, the material cost of extracting metals from the earth and the damage to the earth itself, and the human cost of real physical labor, all base layers that support the casual user.

In recognition of this, one of the performance techniques we employ is to gradually expose the hidden elements and materiality of the technology we are working with in order to build a kinesthetic connection to the often-invisible technology shaping what the audience sees and experiences. Over time we expose Rokoko by showing the full UI (user interface) along with the digital tools available in Rokoko to edit, record, store, and compress the FBX data files used later in Unity. We expose Unity by showing digital avatars freeze as the recorded motion clips finish, explicitly breaking the illusion of digital bodies being physical and "real". We expose the sensor sets in the Rokoko suits by unzipping the textile compartments that hide the black sensor and orange wire pair, further emphasized by the mesh tubing added as a costume design element by Johnna Marin Presby. The Leko lights that light the performance space are shown hanging on tall metal stands normally hidden by curtains. We pull down the tautly hung voile panels on which we project our digital media, transforming them back into 3D textiles from the 2D window into the digital realm they operated as until then. We have the performers drink from water bottles on stage, which breaks a particular concert dance convention wherein performers are only seen as performers, whose physical needs cease existing in that liminal space between pre and post performance. The lighting design progresses in a similar way, moving from monochromatic saturated greens and blues and breaking down into individual CMY hues that, when mixed together at different ratios, produce the initial colors of the piece.

In *Hologram*, early costume aesthetics embraced anti-identity tracking facepaint, and the final version of the Rokoko appliques, material that is attached to but doesn't modify an existing garment, part of the material is reflective glass nanosphere clothing meant to hyper reflect light to obscure cameras, reminiscent simultaneously of safety clothing and superhero costumes (our cast had many Black Widow pose moments).

Hammers and Nails

It can be easy to assume that technology is neutral—that it's simply a tool that can be used for good or bad, depending on who controls it. But some philosophers argue that technology isn't just a passive instrument; it carries embedded values that shape how we interact with the world. Take, for example, the story of Robert Moses' overpasses in New York City. Allegedly, he designed them too low for buses to pass underneath, which meant public transportation—used predominantly by low-income people of color—couldn't access certain areas. While the truth of this story is debated, it captures an essential idea: technology can structure society in ways that reflect the biases of its creators, shaping access, mobility, and ultimately, who belongs where.

Philosopher Don Ihde argues that technology doesn't just function within a society—it creates possibilities or forecloses them. It shapes action, mediating relationships between individuals and their environments. If Moses' overpasses were built as the story suggests, they wouldn't just be infrastructure; they would be gatekeepers, actively controlling movement through the built environment. This concept extends far beyond urban planning—consider birth control, which allows individuals to make decisions about their reproductive futures. In doing so, it redefines agency, shifting pregnancy from an inevitability to an active choice. These technological mediations do more than enable actions; they reconfigure the conditions of existence, structuring power and shaping what is possible. This is the crux of technological mediation: when we experience technology, we experience its effects on our perception, behavior, and agency. Take a hammer. We don't simply see a metal object—we see a hammer for hammering. Its meaning is tied to its use. Edmund Husserl, a key figure in phenomenology, describes this embedded meaning:

> *This world is not there for me as a mere world of facts and affairs, but with the same immediacy as a world of values, a world of goods, a practical world. Without further effort on my part, I find the things before me furnished not only with the qualities that benefit their positive nature, but with value characters such as beautiful or ugly, agreeable or disagreeable, pleasant or unpleasant and so forth.*[36]

We don't just engage with objects as neutral things; we interact with them through a web of meanings that are historically and culturally situated. Martin Heidegger expands on this, arguing that when we use a tool, it disappears from our focus. When hammering, we eventually stop thinking about the hammer in our hand; we think about the nail. Technology, he writes, "withdraws in order to be ready-to-hand."[37]

This dynamic shifts when technology malfunctions. When a tool breaks (a keyboard stops working, a motion capture suit glitches) it becomes visible again, forcing us to recognize it as a mediating force rather than an extension of ourselves. Performer Julie Zalalutdinov describes this process while working with Rokoko motion capture suits: "At first, I couldn't really move with the suit, I felt so restricted; I was really afraid of breaking the suit, of bending my knees, of the headband pulling my hair, or sitting down. By the time we had the show, I felt like my hands and body had been extended, that I was just trying to get my avatar to move how I felt."[38]

[36] Husserl, Edmund. Ideas: General Introduction to Pure Phenomenology. Translated by W. R. Boyce Gibson. London: George Allen & Unwin, 1931.
[37] Martin Heidegger, *Being and Time*, trans. John Macquarrie and Edward Robinson (New York: Harper & Row, 1962), 98–107.
[38] Zalalutdinov, Julie, Interview with the author, 3/10/2025

This is technology becoming transparent, shifting from an external constraint to an extension of the body. Neuroscientific research supports this. Angelo Maritavia and Atsushi Iriki found that when a monkey uses a rake to retrieve food, the visual neurons that usually respond to visual stimuli near the monkey's hand begin responding when there's a visual stimulus at the tip of the rake. The monkey's brain extends its sense of self to include the tool[39]. This is the Body-Machine Loop in action; where the boundary between self and technology becomes fluid, and our tools, over time, reshape how we experience and interact with the world. Philosopher Bruno Latour takes this further, arguing that when a tool is fully integrated into perception, a new hybrid entity is formed. A person using a hammer isn't just a person, they are a hammer-user, a subjectivity shaped by the tool they wield. Monkey + rake = Rakemonkey. Dancer + Rokoko = RokokoDancer. The technology doesn't just extend the body, it redefines interaction, space, movement, and perception. The user adapts to the technology, but in doing so, the technology also disciplines the user, structuring their actions and expectations.

Making the Invisible Visible in Hologram

In Hologram, we use various digital tools, Unity-generated performances, live-streamed motion capture, hanging voile, and stage lighting, not just to present digital performance, but to interrogate how these tools shape engagement. The

[39] Maravita, Angelo, and Atsushi Iriki. "Tools for the Body (Schema)." *Trends in Cognitive Sciences* 8, no. 2 (February 2004): 79–86. https://doi.org/10.1016/j.tics.2003.12.008.

hanging voile fabric in the performance, for example, serves as a metaphor for the very technology mediating this thesis: the screen.

Screens create the illusion of depth. We "go" to a documents folder, "drag and drop" files, "open" and "close" tabs. These verbs imply materiality when, in reality, we're manipulating electrons on a silicon chip. The projected Unity scenes hitting the voile reinforce the flatness of digital spaces, reminding the audience that the illusion of immersion is just that, an illusion. By exposing the wires, breaking the calibration of digital avatars, and stripping off the Rokoko suits, we make the hidden mechanisms of digital embodiment visible. What does it mean for an avatar to be a "body"? Rokoko doesn't capture an individual's essence; it reconstructs data points that approximate movement. The calibration process usually concealed in the backend of the software is revealed, making clear that the avatar is not a seamless digital twin but an algorithmic construct.

When performers tear down the voile, expose the lighting equipment, drink water, and interact with the diffraction of light onstage, they remind the audience of the physical materials that underpin digital experiences; metal, water, gravity, light, screens, and the human body. The seamless illusion of digital performance is built on a foundation of physical labor and infrastructure that often goes unseen. By making the invisible visible, *Hologram* forces the audience to confront the frameworks that shape digital embodiment. As Latour suggests, the goal is not just to use technology but to understand how it configures our interactions, our possibilities, and our ways of being. In doing so, the performance becomes not just an aesthetic experience but a critical interrogation of how digital and physical bodies intersect, mediate one another, and ultimately shape what we understand as embodied experience.

Chapter 6: Conclusions

The Digital is Fluid, but not Limitless

This thesis process has been a pivotal project in my career, both artistic and academic. I have always been curious about how things actually work, and since beginning graduate school, I've felt the push to create work that questions how we, western technological culture, got here. The wonderful gift I didn't know I was receiving in the process of engaging with this work was that it forced me to think about many, many different facets of the world that shape us; technology has a way of doing that.[40] This isn't just a thesis about digital performance, it's a fundamental critique of how digital technology mediates human experience. Investigating *how* motion capture represents movement, but also *what it means* to represent movement at all in a digital space. My favorite philosophy communicator, a YouTuber named Abigail Thorn, made mention in a video essay about social constructs that "When you measure something, you've already decided that there is something there worth measuring."[41] Her point is that the choices we make about how to interpret, measure, and value the world shapes what information we get back from it, and what we do with it. Rokoko software doesn't care about a spine, and I guess here that is because the creators didn't think of the spine or torso as a dynamic, flexible structure of the body, but as a rigid component they themselves rarely use. The actual construction of the suit was clearly designed for men, as the

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[40] For clarity's sake, this is not "do more than *just* dance". It's dance can intersect with the world in amazing ways, just like technology can.
[41] "Social Constructs; or What is a woman really?," posted July 9th, 2021, by PhilosophyTube, YouTube, 7 min., 34 sec., https://www.youtube.com/watch?v=koud7hgGyQ8&t=823s

cast of female-identifying performers will attest to how certain design choices hindered their movement in ways unrelated to sensors or calibration.

This thesis helped me look at mistake as opportunity. Glitch can be both an aesthetic and a methodological tool; reframing miscalibration — turning a supposed failure into a choreographic possibility — feels deeply aligned with performance as an act of resistance, reminiscent of literary theorist Jack Halberstam's concept of Queer Failure - how the absurd can set us free, resist capitalistic pressures, resist conformity, and embrace different models for being and knowing.[42] During this production, we certainly failed a lot. For those considering working with digitally mediated motion capture, my professional advice is to embrace the failure, as it is through failure, mistakes, and glitches that I came to understand my own expectations and values. Failure is not an absolute; it exists only within a specific contextual framework, and over the course of creating and performing this work, my values shifted. Initially, I was drawn to exploring digital glitch as an aesthetic potentiality. However, by opening night, its significance had transformed. Glitch was no longer just aesthetic but a revelatory mechanism of what mattered to the cast and me: our shared humanity and lived experience. It's why we end the work without any projections or technology, with the gesture duets that the cast felt was the most fun.

It also reminded me that embodiment isn't something that exists in a vacuum; it's shaped by technology, training, aesthetics, social expectations, and the physical

[42] Halberstam, Jack. The Queer Art of Failure. Durham: Duke University Press, 2011

realities of labor. I came into this thesis ready to challenge the assumption that digital avatars are passive extensions of the human body, wanting to argue that they reshape our very sense of agency, action, and self-perception. While I still maintain that they are active, I appreciate the fluidity of it not being so clear. I can see value in being undefined, and I'm eager to see these spaces of in-between, how I can take advantage of the interstitial space between 1 or 0. In a post-mortem conversation with cast member Young, we realized that we talked about the avatars of the work equally as he/she/monster dude (keen observers will find him in the figure on p51) as we reference them as it/the recording/etc. That ambiguity is a spark that tells me there's something more to explore and enjoy trying to understand more deeply.

One of the most memorable parts of this experience was seeing the reactions from both my cast and the audience on opening night. When we finished performing, the cast was practically buzzing—jumping around, running back and forth, completely lit up with excitement, despite a few key technological glitches (gotta have some). Everyone was grinning, caught up in this shared moment of joy and exhilaration. We had created something big and different, and the consensus was that it had just been *so* much fun, despite the anxiety and pressure that we felt with our unreliable technology. In discussion with the cast after the concert weekend, what I realized was just how much trust they had placed in me, and how much trust and room to play I had given them. Trust feels like the foundation of this whole process, particularly when working with technology that can't be trusted. There's a warmth in knowing that your cast, your cohort, your mentor believes in you, hands you responsibility, and invites you to build and create alongside them. That kind of trust can feel overwhelming, and gave me a sense of deep responsibility toward the process.

Moving forward, I would like to push even harder on what this means beyond dance and performance. In the creation of this work, climbing the hill of creating this work in a medium that is relatively new to me consumed most of the mental load I had available, so I’ve only been able to hint at topics in discussions of digital labor, military training, and the material costs of technology. Thinkers like Lisa Nakamura, Susan Foster, Don Ihde have helped me see that there’s a deeper argument to be made here about how digital embodiment affects social structures as a whole—how motion capture, gaming, and digital identity can shape the way we think about who we are and what our bodies mean. For example, a topic that came up after discussing the entire process post post-performance with my cast was that the Rokoko suits were clearly not designed with female bodies in mind, and that the publicly available avatars to download that were classified as female shared an aesthetic, long legs, long arms, thin, short torso, strict proportions, something that we didn’t have space to explore within this version of the work. But regardless of the next direction I take, I know that I’ve had a truly invaluable learning experience working in this medium, and there is so much more to question and explore.

Appendix

Fig 1. An example of Unity software. Top right is the Scene, below is the project console where files and materials are stored and accessed. Right is the Hierarchy, which shows everything in the scene, and below is the inspector, where users change aspects of the elements in the scene. Screen-capture by the author.

Fig 2. A collection of digital avatars all mid movement, performing different clips of motion capture data. Screen-capture by the author.

Fig 3. The leg in question, Emma Vanderlinde's miscalibration sequence repeated four times around a central avatar performing Kevin Carroll's miscalibration sequence. Screen-capture by the author.

Fig 4. Dancer Macko is held at a diagonal by Vanderlinde and Young with an avatar projected onto voile behind. Photo by Taneen Momeni.

Fig 5. A list on a whiteboard of the gestures created by Emma Young and Julie Zalalutdinov. Photo by the author.

Fig 6. Stage Configuration for hologram. Before the main curtain is opened at the beginning of the performance. Photo by the author.

Fig 7. The opening live-stream solo performed by Emma Young, showing stage configuration and locations of hanging Voile. Photo by the author.

Fig 8. Rokoko suits with applique on front, and wires exposed. Photo by Taneen Momeni.

Fig 9. Dancer Vanderlinde wearing the grey leotard next to Young, wearing athletic wear. Photo by Taneen Momeni.

Fig 10. Dancer Vanderlinde carries Macko while they are entangled in voile. Photo by Taneen Momeni.

Fig 11. Dancers Zalalutdinov and Young performing in front of the projections of their avatars in their duet. Photo by Taneen Momeni.

Fig 12. Dancer Young following “Monster dude” during the section Quadrants. Photo by Taneen Momeni.

Fig 13. Collection of dancing avatars during the Quadrants section. Screen-capture by the author.

Fig 14. Cast dancing behind a single voile panel near the end of Quadrants section. Photo by Taneen Momeni.

Fig 15. The initial setup of the Rokoko software interface users record, watch, edit, and export mocap from. The figure in the center is the avatarial stand-in for the person in the suit. Screen-capture by the author.

Fig 16. An avatar performing Vanderlinde's backbend when miscalibrated. Screen-capture by the author.

Fig 17. Dancers Vanderlinde and Young hold up Macko as Macko's avatar calibrates on the voile panel behind. Photo by Taneen Momeni.

Fig 18. Dancer Zalalutdinov performing her solo with Rokoko suit hanging off the body. Photo by the author.

Fig 19. Performer Julie Zalalutdinov behind the Voile panels attempting to match the movements of the projected dancing avatars. Photo by Taneen Momeni.

Fig 20. The full cast performing their gesture duets during the final few moments of the show. Photo by Taneen Momeni.

Fig 21. Dancers Zalalutdinov and Vanderlinde hold a voile panel sideways while Macko and Young dance behind, causing a cascade of different colors of light. Photo by Taneen Momeni.

Fig 22. Dancers Macko and Zalalutdinov near the boxes of water stage right, magenta on Macko and cyan on Zalalutdinov. Photo by Taneen Momeni.

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