Tangible Tomorrow

Moving Beyond Screens

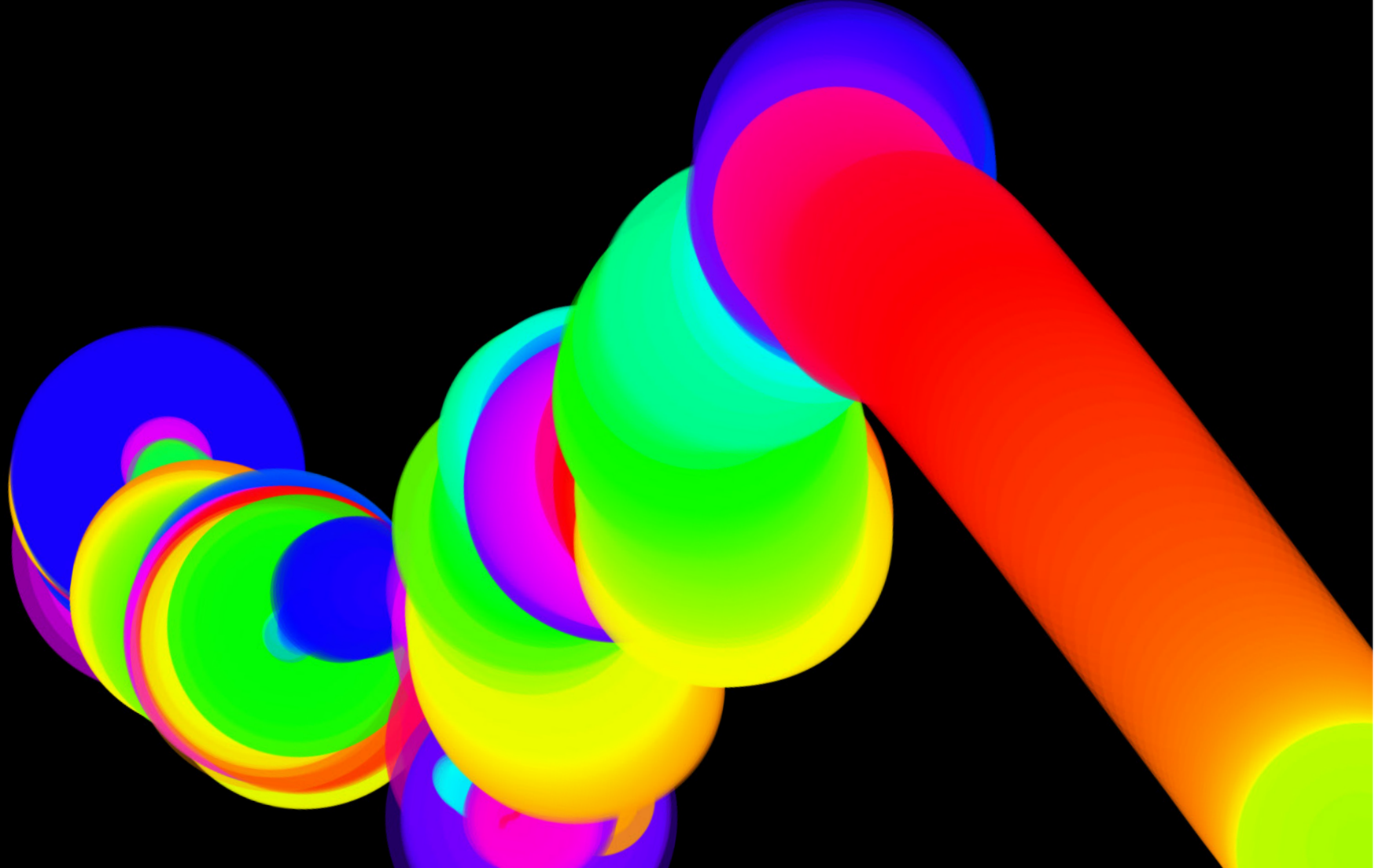
Jawad Farooq Naik

Thesis, Dynamic Media Institute
Massachusetts College of Art and Design

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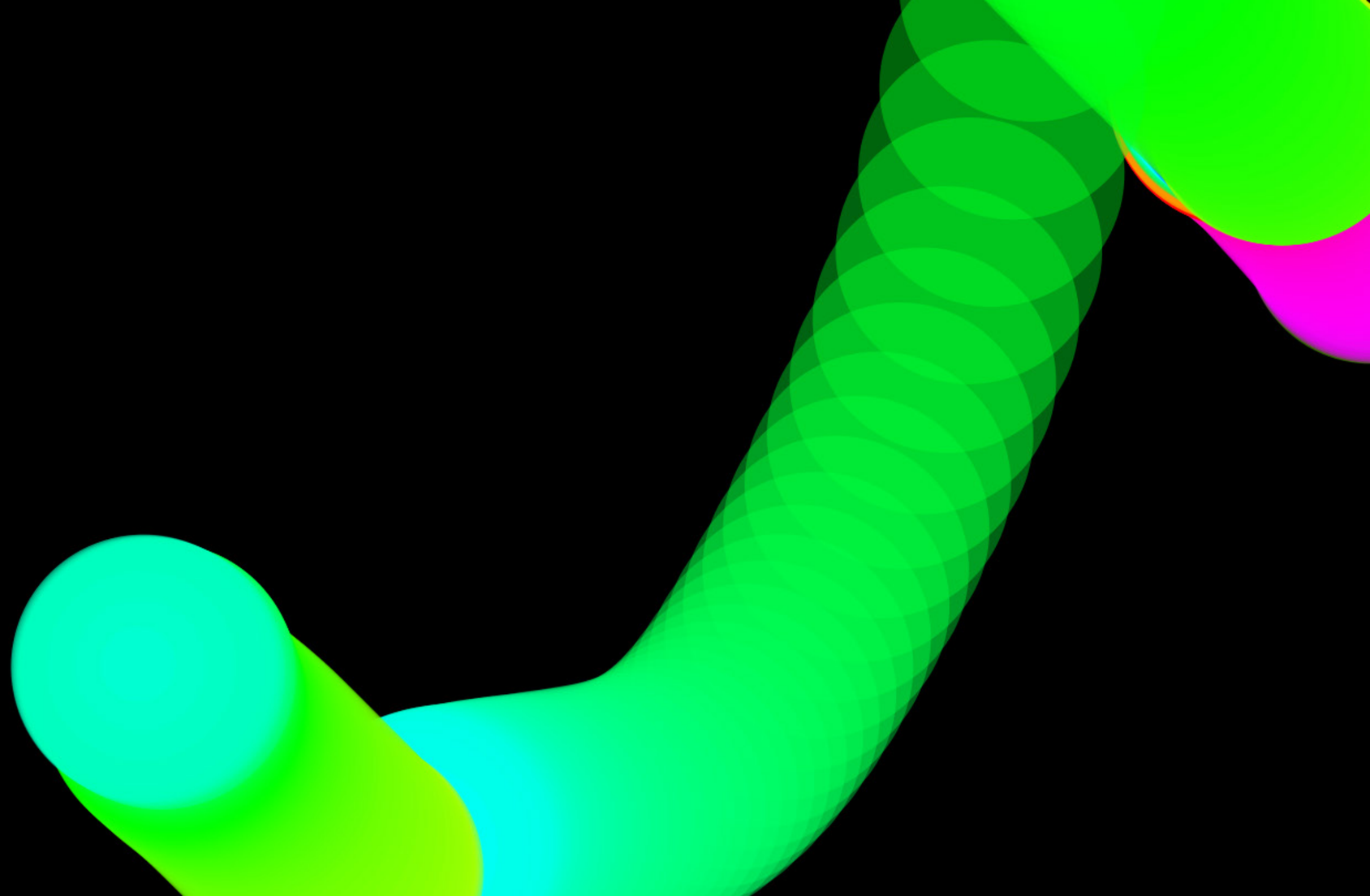


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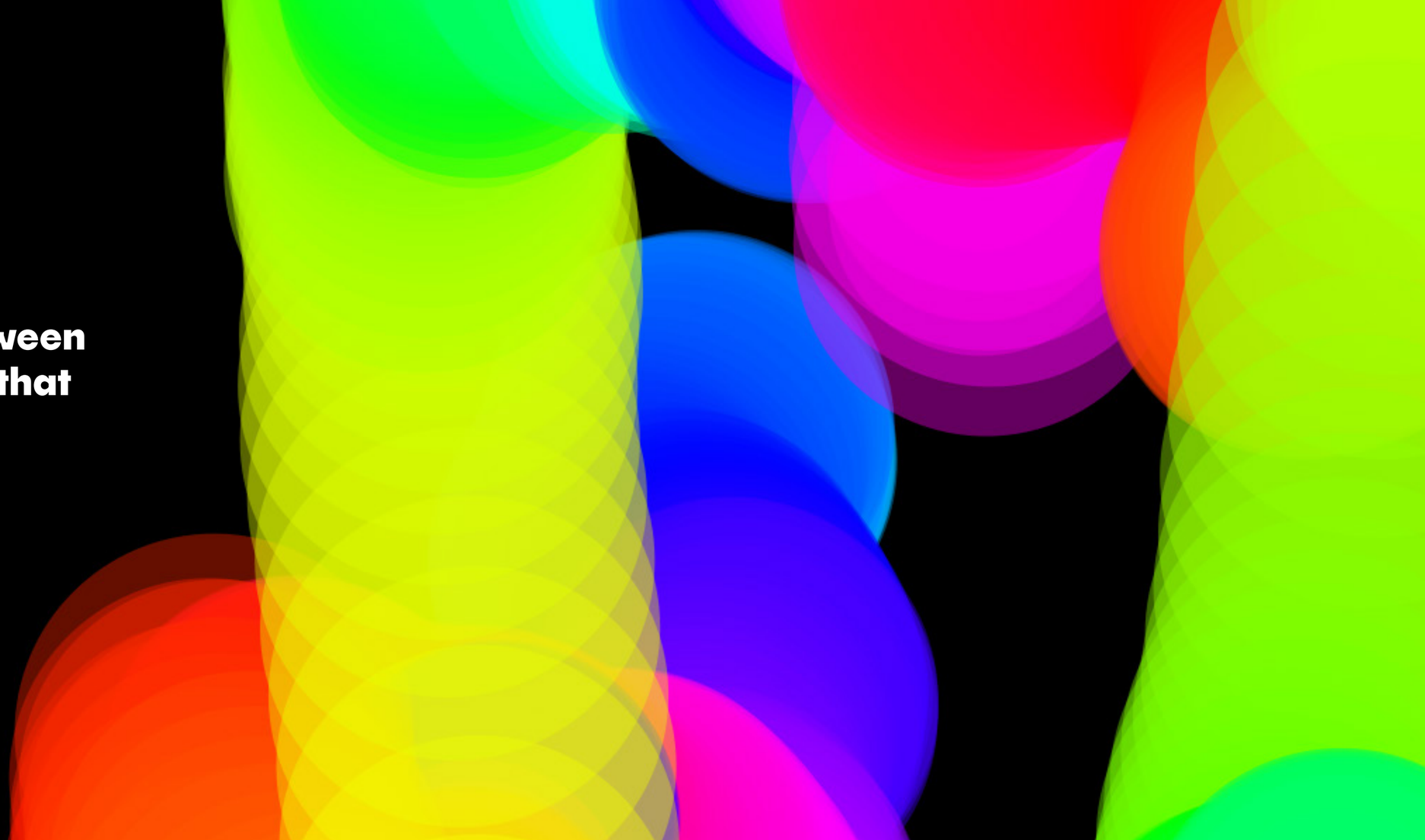
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Dynamic Media Institute
Massachusetts College of Art and Design



“Bridging the miles between hearts with technology that makes every moment together count.”

Jawad Farooq Naik



This thesis is submitted in partial fulfillment of the requirements for the degree of Master of Fine Arts and approved by the MFA Design Review Board of the Massachusetts College of Art and Design, Boston, Massachusetts.

May 2025



Photo of the author by: Maha Khan

Extending my heartfelt gratitude to:

my mentors and guides for their remarkable guidance and steadfast support throughout this journey.

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Diego Guzmán Villada
Kisholay Mohanta
Miaowen Liu
Fadil Cantave

Fish McGill, Program Director
Associate Professor of Design
Director, Dynamic Media Institute, MFA
Massachusetts College of Art and Design, Boston

Joseph Quackenbush, Writing Advisor
Professor of Design
Chairperson, Communication Design
Massachusetts College of Art and Design, Boston

Tim Scholl, Project Advisor
Visiting Lecturer
Massachusetts College of Art and Design, Boston

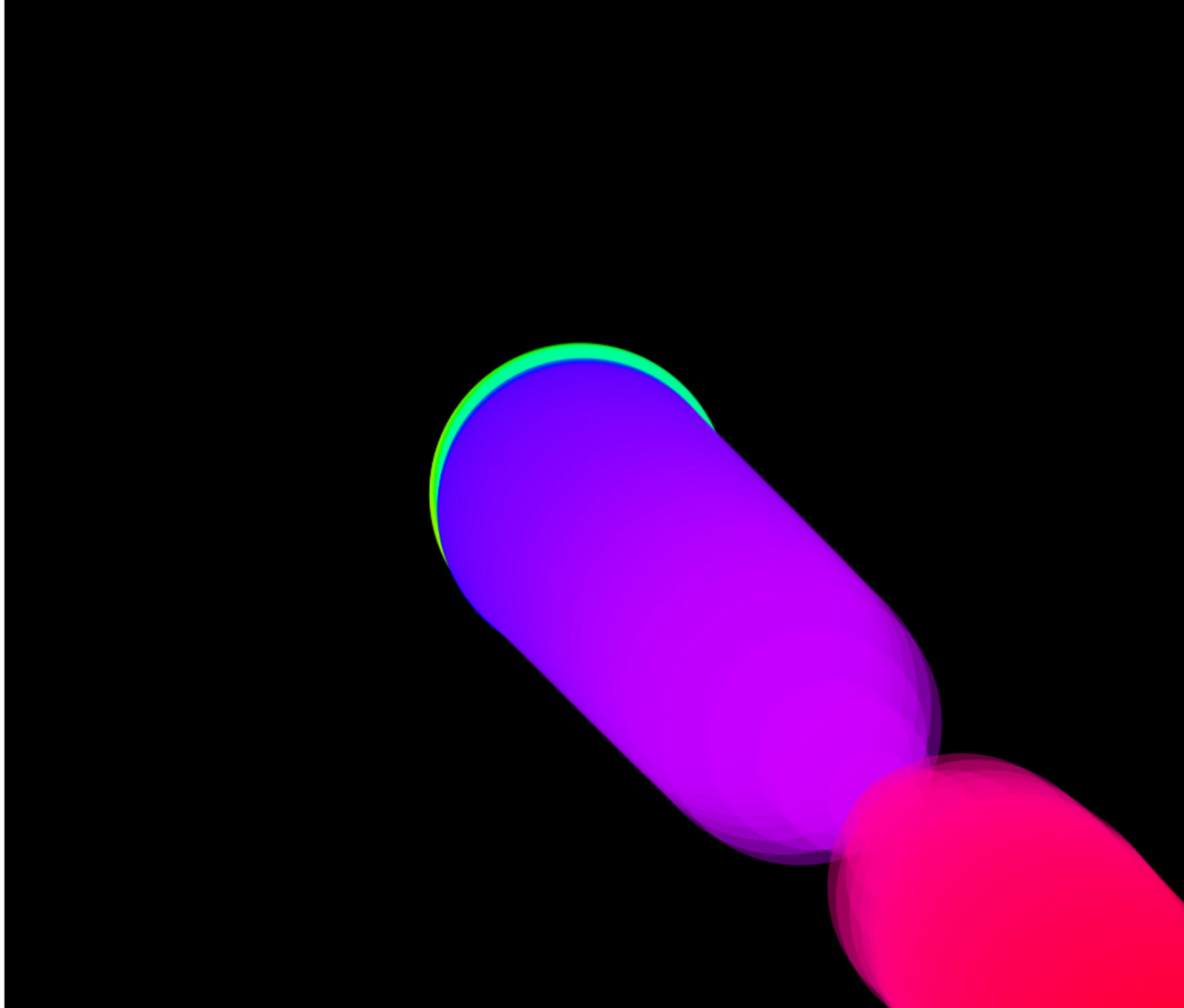
Nandini Srinivasan, Writing Advisor
Visiting Lecturer
Massachusetts College of Art and Design, Boston

Fred Wolflink, Project Advisor
Assistant Professor of Design
Massachusetts College of Art and Design, Boston

Abraham Evensen Tena, Advisor
Associate Professor
Massachusetts College of Art and Design, Boston

Dedications

This thesis is dedicated to my cherished family, whose unwavering support and love have been the cornerstone of my journey. I honor my grandparents, Ihsan Ullah Naik and Shamim Ihsan Naik, whose enduring legacy continues to inspire me even in their absence.
My heartfelt gratitude goes to my parents, Farooq Ihsan Naik and Naila Farooq, and to my siblings—Hina Farooq, Bushra Farooq, and Rimsha Farooq—whose steadfast encouragement has sustained me through every challenge. I am especially grateful to my wife, Maha Khan, whose unwavering support, deep love, and remarkable patience throughout our long-distance journey inspired and guided this thesis. In the midst of that transformative time, our son, Rafael Jawad Naik, was born, marking a new chapter of joy, while my daughter, Mirha Jawad Naik, continues to brighten our lives.



Foreword

Human connection is intangible; the space between us occupied by our words and emotions can feel either empty or full depending on the circumstances surrounding our busy lives and the people around us. While Jawad Farooq Naik's life in Pakistan was not focused on this fact before coming to the Dynamic Media Institute, it would define his experience there and shape the course of the book you now hold in your hand.

I worked with Jawad through three of his four semesters at Massachusetts College of Art and Design. As a DMI alum, faculty advisor, and professional product designer, I had the pleasure of helping guide Jawad through his thesis development. Jawad's path through this story was like the hero's journey, made not with a map but a compass. He was an inveterate explorer, following a north star through his many experiments. He didn't necessarily know which path he would take with each project, but he found his way, always guided by his connection to his family back home. Each of these projects represents a struggle for human connection across a distance and how to make the invisible space between us more perceptible.

Today, I am excited to invite you to follow our hero's voyage from the known into the unknown and back home again from the intangibility of human connection into a more Tangible Tomorrow.

Tim Scholl

When I first began working with Jawad Farooq Naik on Tangible Tomorrow, I expected to support him through the usual stages of refining ideas, shaping narratives, and clarifying language. What I hadn't expected was how his work would stay with me. Tangible Tomorrow asks—how do we stay close when life pulls us apart? It answers through form.

Having watched an evolution of long-distance connection through parents who immigrated here decades ago, I remember the intensity of 15-cent-a-minute phone calls placed in the middle of the night to family in a different time-zone—and now, the ease at which I can look at them face to face on an early morning. The change was not just technical—it was emotional, cultural, human. Jawad's work lives here. It exists as a juxtaposition between mechanical and intimate.

I'm honored to have accompanied him on a small part of this journey, and invite you to read Tangible Tomorrow.

Nandini Srinivasan

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Preface

I've always loved traveling to new places— taking in the landscapes, absorbing different cultures, experiencing the unique art, and design. The United States had captured my imagination since my first visit in 2013. I remember being intrigued by its diversity, technological innovations, and educational opportunities.

Little did I know that making the decision to study abroad would unravel all I'd grown accustomed to, sweeping me into a whirlwind of emotions and unforeseen trials. What began as a thrilling pursuit of learning morphed into an emotional tightrope walk. Visa complications meant I was suddenly separated from my wife and child, forcing us into a long-distance relationship neither of us had anticipated. Gone was the security of our routine; in its place came frustration, heartache, and an unrelenting sense of absence.

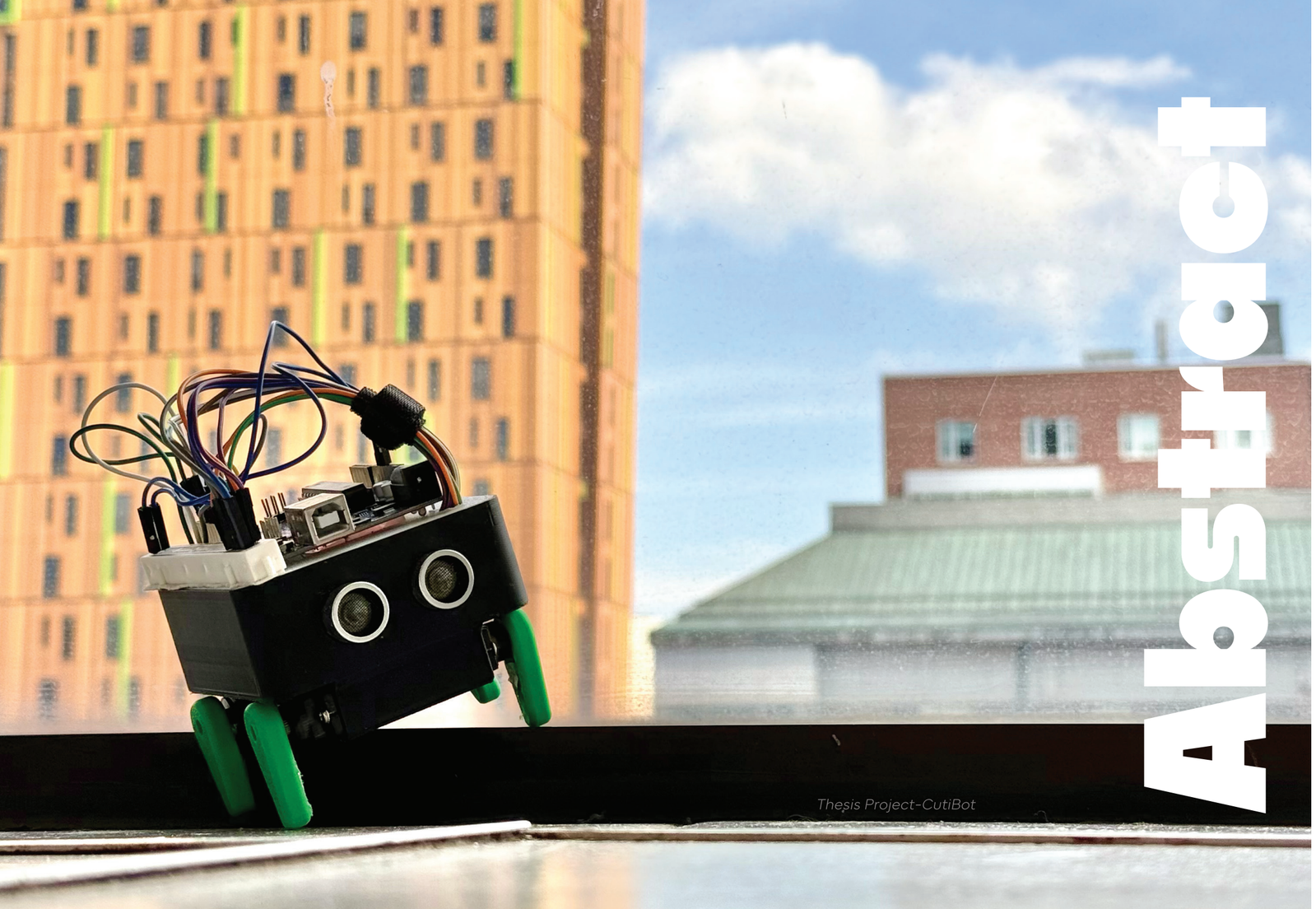
What made the distance even more difficult was the relentless and frustrating reality of mismatched time zones. When I woke up, they were heading to bed. When they were free to talk, I was caught up in lectures, critiques, or meeting deadlines. We tried to sync schedules, to carve out time for daily video calls, but even those felt like shadows of the life we once shared— strange, digital shadows. Conversations were often hurried, distorted, pixelated, or interrupted by lag. The silence after a call ended always felt heavier than it should have. I remember the aching stillness of my apartment after hanging up—staring at the same screen that had just flickered with my family's faces, now blank again. Their presence could be turned off with a click, as if they were just data.



Screenshot of a videocall with my family in 2024

There's an emotional toll that no one prepares you for when it comes to long distance relationships— whether they be friendly, romantic, or familial. It's the loneliness that seeps into small moments. The way simple joys, like coffee in the morning, begin to feel muted without someone to share them with. There were nights I lay awake wondering if my young child would still remember the sound of my voice. I was only able to communicate with her verbally, and I wondered if a hug could ever be compressed into words, if a screen could carry warmth. No matter how many emojis or heart reactions we exchanged, they never quite filled the gap.

There's a particular kind of grief in knowing the people you love are just a call away but feel a world apart. It was through this deeply personal struggle that my thesis began to take shape. And, though it stemmed from my personal response to the loss I felt, I soon realized that this wasn't just my story. Millions worldwide grapple with similar separations for several reasons— some of which are by choice, and some of which are not. While separated from loved ones, I leaned into my creativity. Through art, design, and the integration of technology, I aimed to enhance communication—to bring people closer in ways that standard tools didn't. I wanted to simulate the unspoken comforts: the small gestures, the reassuring presence, the sense of truly being with someone. This book is a record of my personal journey—the creative sparks, the practical challenges, the "aha" moments that made my work into what it is. However, I also hope it can stand as evidence that our tech-driven world can transcend mere information-sharing, allowing us to connect on a level that feels authentically human and emotionally rich.



Thesis Project-CutiBot

Abstract

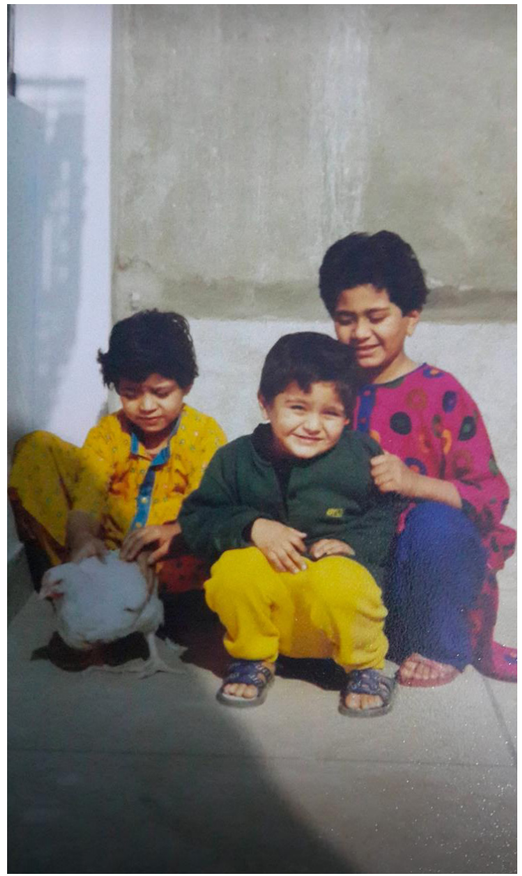
For centuries, humans have ventured across borders and oceans—driven by growth, the pursuit of knowledge, the hope for a better life. While globalization and modern technology have made the world feel smaller, millions still contend with the daily weight of physical and emotional distance. Even as modern communication has evolved from handwritten letters to real-time video calls, to shared virtual reality environments, modern communication innovations represent a paradox. Devices like smart phones promise closeness but are often pointed to as the cause of isolation and loneliness.

As human beings, our connections flourish through a spectrum of senses—touch, scent, even subtle gestures. But, in a world dominated by screens and notifications, those essential layers of closeness can slip through the cracks. Instead, we are overwhelmed with distractions, diminishing the sense of intimacy we crave. The story I shared above, the sudden distance I experienced from my wife and child, led me to develop Tangible Tomorrow, an exploration of how art, design, and creative technology can recreate the nuances of physical togetherness through multisensory experiences.

By incorporating tactile and olfactory elements alongside sound and vision, this body of work challenges the idea that modern communication must be limited to words or images on a screen. Instead, it reimagines how we might truly "feel" one another's presence, no matter the distance. This work speaks to our shared longing to remain deeply connected despite life's many separations. Through immersive design and dynamic media, I hope Tangible Tomorrow will offer a new lens into how we can nurture relationships in a world where distance is both a common reality and a significant challenge. After all, real presence isn't merely about being side by side; it's about how we continue to feel each other's closeness, even when we're far apart.



Intro duct ion



The City That Shaped Me

I was born and raised in Lahore, Punjab, a city woven from centuries of history, culture, and innovation. With over 13 million residents, Lahore stands as Pakistan's second-largest city. Its long, storied past mixes with the rhythms of modern life in the most extraordinary ways.

Known as the "City of Gardens," Lahore is full of lush green spaces, and Mughal-era architectural marvels. The grand Badshahi Mosque, the imposing Lahore Fort, and the elegant symmetry of the Shalimar Gardens were never just historical curiosities to me; they were places where I first learned the fundamental language of design, long before I understood the word "design" itself. Exploring their courtyards, arches, and pathways felt like stepping into living classrooms, each with its own story to tell.

However, Lahore goes beyond its timeless landmarks. It is the cultural heartbeat of Pakistan, and it has nurtured generations of artists, poets, and performers. The Lahore Museum invites visitors into centuries of Gandhara sculptures, miniature paintings, and rare manuscripts. Whenever I wandered through its halls, I sensed an unspoken dialogue with the creators who came before me, each tangible artifact bearing silent witness to countless imaginative journeys.

The city honors its past, but it also embraces the future. A skyline punctuated by contemporary architecture, a growing metro system, and flourishing tech startups stand as proof of the city's forward-thinking spirit. Lahore is a bridge between tradition and progress. And then there is the food—an art form all of its own. The robust spices of Lahori biryani, the smoky charm of Gawalmandi's kebabs, and the warm solace of a halwa puri breakfast on a street corner all speak to the city's richness. These are the sights, smells, and sounds that are ingrained in me, the ones I found myself longing for once I was distanced from them.

For me, Lahore embodies the paradox of embracing heritage while fearlessly chasing progress. It was within this tapestry of old and new that my creative philosophy took root. The city didn't just give me a place to call home; it shaped the lens through which I see the world, and it cemented a belief that art,



Badshahi Masjid a heritage site in Lahore, Pakistan



The iconic Minar-E-Pakistan in Lahore, Pakistan

design, and technology are powerful forces—capable of forging connections, sparking transformation, and inspiring people far beyond the city's ancient walls.

The Hum of Machines & The Scent of Fresh Ink

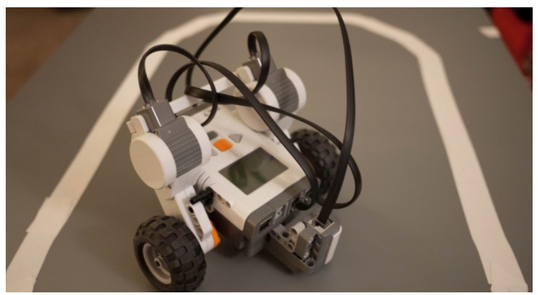
My fascination with creativity and craftsmanship took shape next to a rhythmic hum of machines, and the scent of fresh ink, at my family's offset printing business, PrintVision. I used to spend hours roaming the facility— entranced by the way blank sheets of paper morphed into vibrant prints, each carrying and communicating its own story, purpose, and vision. It felt like I had stepped into a world where ideas became tangible, a process that felt nothing short of magical to me at that age.

At the print facility, it was the prepress section that captivated me the most. There, I encountered the Apple Macintosh II—a sleek machine that felt futuristic at a time when personal computers were still rare in Pakistan. My initial interactions with the Macintosh were mostly about sneaking in some game time, but as I observed more, I realized technology could enhance creativity rather than replace it.

There were other aspects of my childhood in Lahore that helped forge the pillars of my creative philosophy and practice as well, like my involvement in the after-school robotics club. As I got a bit older, I began engaging in projects like building robotic arms, and programming LEGO Mindstorms (line-following robots). My fascination with machines and mechanics developed into a curiosity around dismantling and rebuilding. Activities like these nurtured in me an instinct to break, reimagine, and improve. All these formative experiences instilled in me an enduring lesson—that creativity is dynamic, ever-evolving, and inextricable from technology.



Die Cut Machine at PrintVision

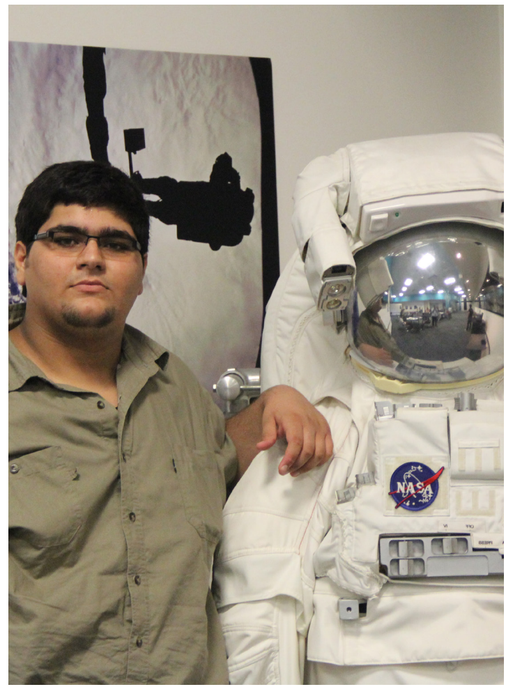


LEGO Robot Photo Source: peterklemperer.com

Exploring, Evolving, and Redefining My Path

I embarked on my first international trip at 18 years old, in 2013. It was a transformative trip to the U.S, as part of a school-organized internship at NASA's Lyndon B. Johnson Space Center in Houston. The experience ignited a lifelong passion for travel and discovery.

Over the coming years, as I traversed nearly every state in the U.S., I immersed myself in diverse cultures, breathtaking landscapes, and an atmosphere charged with innovation—each journey subtly reshaping my creative vision. My wanderlust soon carried me beyond American borders. I ventured to the United Kingdom, the United Arab Emirates, Turkey, Saudi Arabia, Malaysia, and even Canada, where every destination revealed its own unique blend of artistic expression, architectural marvels, and cultural traditions. These experiences reinforced my belief that design is a universal language—one that evolves with heritage yet is constantly reinvented through modern innovation. And, I could never shake the quiet restlessness inspired by all the traveling, the vibrant experiences and technological advancements I had witnessed abroad. It was a wanderlust that would lead me back to the U.S years later.



Jawad at NASA's Lyndon B. Johnson Space Center 2013

Formal Education: Choosing Art School

I was incredibly fortunate to grow up with parents who recognized the value of design. With their unwavering support, I eventually decided to attend The National College of Arts (NCA) in Lahore, where I majored in Visual Communication Design with a minor in Film Studies. It was a blend that required me to merge storytelling, design, and cinematic language. The college's Bauhaus-inspired curriculum fostered a multidisciplinary approach, compelling me to embrace art, design, and craftsmanship as interconnected languages. It was here that I feel I discovered my creative voice. There were lessons I learned at NCA that I have carried with me into my current creative practice, into this thesis.

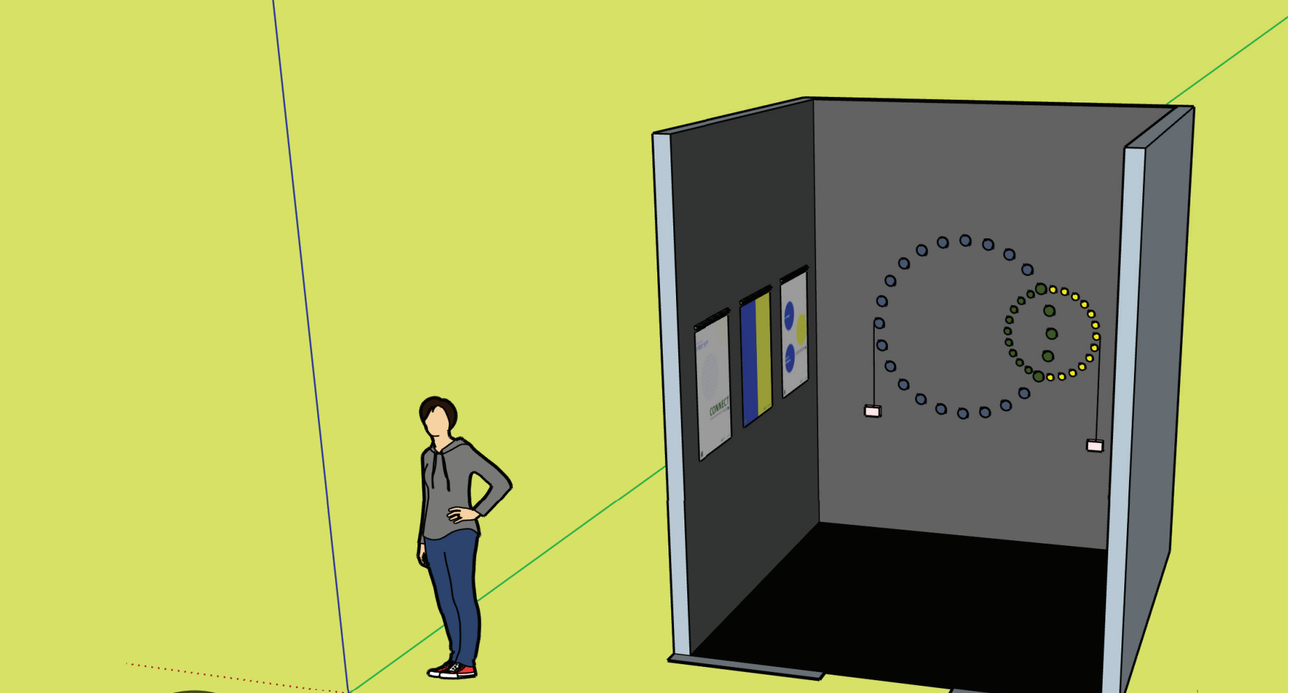
I'll never forget a project for a class that involved sculpting a toy out of limestone. I chose to carve a plush toy—deliberately choosing to contrast the softness of fabric and the rigidity of stone. That physically demanding yet deeply rewarding project challenged me to appreciate an unexpected dialogue between seemingly opposing materials—one soft, one hard; one warm, one cold. Work like this implanted the sort of thinking that made me wonder almost a decade later—can the coldness of a screen carry warmth? Can a physical hug be compressed into words? Another project that profoundly impacted me was creating an experiential soundscape to capture the internal world of those experiencing schizophrenia. By layering audio distortions, fragmented voices, and disoriented spatial sound, I was able to immerse listeners in an altered reality. This endeavor expanded my perception of design—it wasn't just about the visual; it could shape emotions and perceptions in multidimensional ways.

Beyond the classroom, my time at NCA was alive with extracurricular experiences, many of which were creative by nature. I joined the Puppeteers Society, which deepened my understanding of performance-based storytelling, and even stepped in front of the camera for a film with the End Film Society. I was immersed in an interdisciplinary culture that valued every facet of creative expression, and I learned that communication and connection with people, or an audience, can come in many forms.

After graduating college, I went on to work in the design industry, at advertising agencies, creative studios, even my family's print business. Along with co-founding and starting my own creative studio, Pinn.Media, I started my own family. And it wasn't long before my wanderlust kicked back in. I began to yearn for fresh perspectives, and deeper engagement with technology. My passion for travel, and desire to grow as a creative, as a designer, and as a person, led me to pursue a master's degree in the United States.



NCA Main Gate Source: Nca.edu.pk



Common Threads

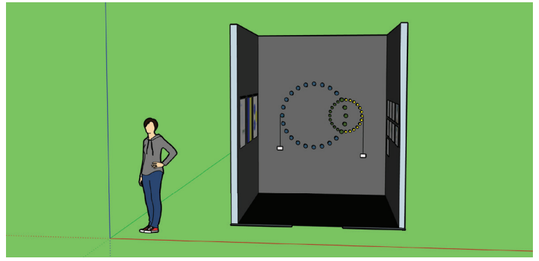
NCA Thesis Installation 3D Render

Since you are reading this book, you obviously know where, exactly, I ended up—The Dynamic Media Institute at Massachusetts College of Art and Design. Where Tangible Tomorrow took shape.

To better understand the evolution of Tangible Tomorrow; the recurring themes and common threads, I must delve into one last project from my days at National College of Arts in Lahore—my final project at the school. It was a conceptual branding project, aimed at bridging the communication gap between parents and children through interaction and play. The branding initiative was developed for a hypothetical, speculative conference, hosted by a preschool in Punjab. The reason I highlight this project is because it planted the seeds for one of the key themes in my work, human connection. At the heart of this project was a key visual metaphor, composed of two overlapping circles—a larger circle in calm, stable blue, to symbolize a parent's nurturing qualities, and a smaller circle in warm, energetic yellow, to represent a child's curiosity and vitality.

In the place where these circles merged, a vivid, green, "safe space" was formed, serving as a metaphor for the harmony and empathy that arise when both parties genuinely engage and connect. This motif appeared in a variety of designs for the campaign—like interactive posters where onlookers could move acrylic plastic shapes around; a collaborative installation where shapes were projected using light; a touchscreen exhibit where both parent and child could connect shapes together on a screen; even social media prompts, where parents and children were invited to discover, collaborate, and talk. Though the project did not address physical distance, it certainly addressed an emotional and generational one. It also underscored the power of playful design and nonverbal cues to bring people closer—a concept that would later guide my own project work at DMI.

While my undergraduate project focused on bridging the emotional distance of generational differences between people in a single household, my work evolved to tackle themes of both emotional and physical distance experienced when loved ones are physically apart. As I've highlighted in the beginning of this thesis, living in the United States while my family remained in Pakistan exposed me to the limitations of our hyper-connected digital world. Even though technology enables us to see,



NCA Thesis Installation 3D Render

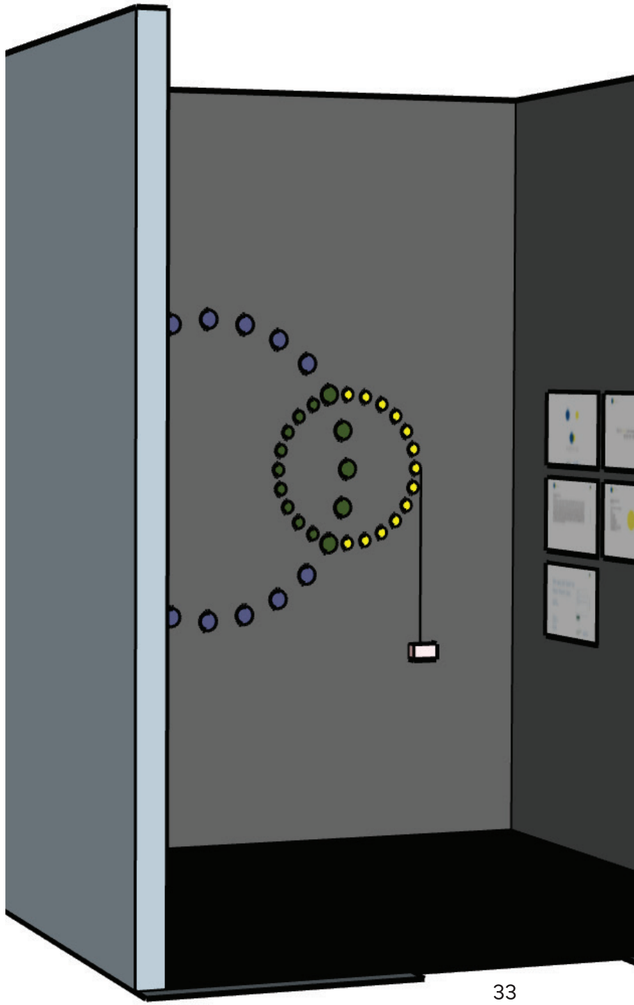


Pulsepaint at FreshMedia

hear, and speak to one another instantly, there are aspects of connection and communication that are missing—the subtle nonverbal cues, the comforting warmth of a touch, the quiet intimacy of a shared silence, the reassuring pressure of a hug. They remain out of reach.

In my work at DMI, I built on these same principles of interaction and play in design, but worked to integrate additional sensory elements like touch, scent, sound, tangibility, and motion, to create experiences that simulate physical presence in ways traditional screen-based communication often overlooks. Experimenting with different materials and interactions in my undergraduate branding project laid the groundwork for my approach here at MassArt.

During my time at DMI, I developed a series of projects that harness multisensory experiences to bring people closer. Ultimately, my work underscores a personal belief that technology can go beyond mere information exchange. It can restore the spontaneity, warmth, and empathy inherent in face-to-face encounters, even across thousands of miles. In the chapters that follow, I will delve further into these ideas, with the goal of creating a roadmap toward transforming our digital interactions to feel as genuine, heartfelt, and deeply human as real-life connections, even when we are far apart.




Data · trends.
Enlightment.
Research.
Innovation
In Search.
Thinking.
Experiment
Tinkering.
Uncanye
Assumptions
Critical Design
Speculation.
Fiction.
Generation.
Anything that Serves a purpose
Building Thought Process
cognitive.
experience
speculation
expressions.
negative.
positive.
Imagination
Touch
feel
smell.
see
hear
taste
For the user. by the designer For Future Production
Functional
Making Fiction Design Proposed to come up with Design ideas for everyday things.
too Futuristic. & confused.
Reasoning.
Journey.
connection
it relates and connect
Navigation
Path! right or wrong
are you?
you are here now.
EMPATHY
Sympathy
Reason?
Relation
you are here now?
are you really here
you can have new and can be in these Shoes too?
they are judged and looked upon.
my biggest battle Journey?
Direct correlation
weight loss.
weight loss.
Excercise.
Diet control
hormonal therapy.
change of life style.
mockery
D. Seminar I
Prototyping.
JAWAD
Freedom is an; Illusion to Keep you under control.
Surveilling Data & using it to market goals and services against human right.
Politics effects us on macro & micro level
Concepts
Reasoning
connection
Politics
Leadership
Control
Identification
Verification
Deterministic
Illusion
Reflection
Identity
Privacy
Privacy is a right. A Basic Right!
CAUTION
YEAH!
You have entered the happy area
Keywords
Development.
Surveillance
Observation
Intelligence
connection
Economy
Human Roles
Humans.
Invasion!
Freewill
Power.
Design plays a major role in living being
Marketing is. Manipulation in Disguise.
Impact
Reaction
Experience.
Acknowledgment
Interpretation
Interaction
Ergonomic
Wonderful
Pleasing
Usability
Aesthetic
Functional
Reciprocate
Comfort
Symbiotic
Imagination
Stories
Intuitive
Aesthetic
Emotion
Frustrating
Silly
Bored
Excited
Grateful
Curious
Creative
Pleased
Anxious
Love
Hatred
Seal
Comfort
Purpose
Freedom
Information
Experience
Feelings
Movement
Working
Privacy
Sensing
Sight
Touch
Taste
Smell
Hearing
Balance
Proprioception
Vestibular
Interoception
Pain
Temperature
Thirst
Hunger
Sleepiness
Air Hunger
Nausea
Urge to Vomit
Full Bladder
Need to Defecate
Sexual Interest
Itch

Primary Research

Questions

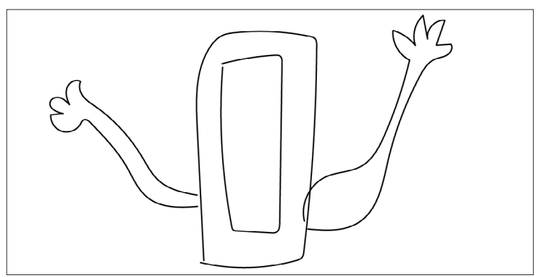
The survey included 55 questions ranging from multiple choice, to write-in, to the opportunity to share a personal sketch based on a prompt. It included general questions about the individuals' LDR— whether it was romantic, familial or friendly, how long they had been apart, how often they communicated with the people they were distanced from. The survey also included a variety of questions around communication tech usage—What specific tools and technology they used to communicate? Why did they like them? How satisfied were they with them and why?

Additionally, the survey posed questions related to any potential challenges respondents may be facing or have faced in connecting and communicating successfully in LDR's. The level of detail in these questions ranged from general, to more detailed, and covered subtopics like symbolism and language in communication, as well as multi-sensory communication. A few examples include;

"Do you find emojis and text messages to be effective in expressing emotions, why or why not?"

"How important is physical presence in emotional communication?"

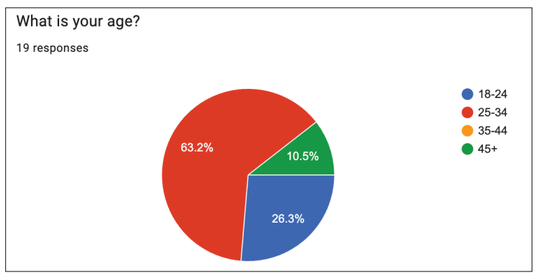
The second half of the survey included questions focused on the specific projects further detailed in my case study. They were specifically structured to help assess how individuals might react to aspects and concepts of the designs before actualization. Because my work focuses on multisensory design, tangibility, and simulating physical presence, I wanted to know—how might individuals react to receiving multisensory information that was non-verbal from the person they are distanced from. All of these questions were based on specific concepts for products and designs explored further below. One question asked—if they had a pillow that could emit some aspect of their partner or loved one, what would they feel most comforted by? Their heartbeat? Their temperature? Their breathing rhythm? The last question in the survey prompted users to draw a tool or device that would help them feel closer to their partner or person while apart. What would it look like? and how would it function?



Respondent 9 envisioned a phone with robotic arms capable of mimicking hand movements.

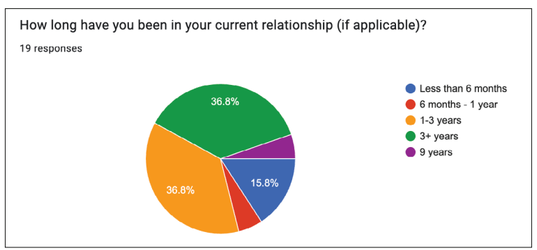
Demographics

Twenty individuals responded to the questionnaire I sent out, including family members, relatives, close friends, acquaintances, and students from MassArt. Their ages ranged from 18 to 65, with most falling between 18 and 34. The group represented a mix of digital natives and individuals who had witnessed the rapid technological shifts of the past two decades. Participants came from diverse ethnic backgrounds, offering perspectives shaped by a variety of cultures, traditions, and values. This diversity added meaningful depth to the research—especially in understanding how cultural nuances shape the emotional dynamics of long-distance relationships.



Most respondents were in committed relationships that varied in duration from a few months to over three years. Others were single or navigating undefined complexities within their friendships and romantic relationships, reflecting the diverse spectrum of relational contexts. Responses to what kind of tools individuals used to keep in touch highlighted an expected, but important commonality: a reliance on digital tools for communication, regardless of relationship type. Participants described themselves as moderately to highly tech-savvy, with many spending upwards of three hours daily on devices such as smartphones or laptops. Social media platforms, especially Instagram, WhatsApp, and Facebook, were the preferred avenues for maintaining relationships, primarily for sharing updates and casual interactions. However, despite frequent use, these tools were deemed insufficient for creating emotional intimacy, revealing a striking disconnect between convenience and emotional depth.

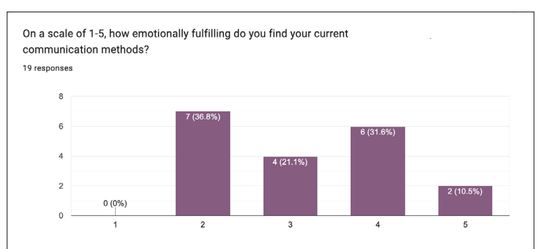
"Want to be physically around my partner so that we can witness each other's lives rather than talking about things on text, and also because I love the idea of going on dates". —Questionnaire Respondent 2



The Emotional Void in Long-Distance Connections

One of the most consistent themes that emerged was the emotional gap created by physical absence, which no amount of messaging, video calls, or social media interactions could adequately bridge. When asked if specific modern communication tools were effective, participants voiced frustrations with the superficiality of current technologies, describing them as unable to replicate the warmth and nuance of in-person interactions. While video calls and texting were frequently used, their emotional resonance was often rated low, with most respondents scoring these methods around 2.5 out of 5, 1 being not fulfilling at all and 5 being extremely fulfilling.

Respondents lamented the inability of these tools to capture a certain essence of the other person. One participant articulated this poignantly: "No technology can replace the energy of someone being physically beside you." This sentiment was shared by others, with participants emphasizing the absence of tactile feedback and shared in person experiences. The feeling of emptiness was amplified during significant moments, such as anniversaries or personal milestones, when physical presence holds the most meaning.



Psychological Challenges: Loneliness and Misinterpretations

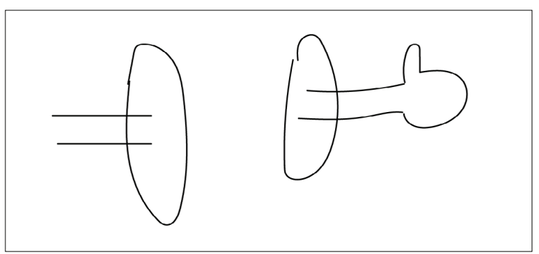
The toll of long-distance relationships on mental well-being emerged as a recurring theme throughout the responses. When asked, "What are the biggest challenges you face in maintaining closeness in a long-distance relationship?", nearly 70% of participants mentioned feelings of loneliness or emotional isolation. These experiences were often heightened during stressful periods or meaningful life events—times when the absence of a partner felt heavy.

Many reflected on the difficulty of navigating such moments without tactile closeness or shared physical routines, describing a persistent sense of longing that couldn't be fully resolved through calls or texts alone. One participant shared that even small rituals, like brushing teeth at the same time or watching a show together, felt hard to sustain over distance, which made everyday connection feel fragile. Another mentioned, "It's not the big things—it's not being able to reach for their hand when I'm overwhelmed," pointing to how emotional support often felt delayed or flattened in virtual spaces. The emotional distance, while invisible, was deeply felt.

When discussing experiences and challenges with digital communication, individuals mentioned that misunderstandings were common due to the lack of non-verbal cues. The responses to emojis were interesting. While some respondents felt that they were limited and prone to misinterpretation, others felt that they communicated more than just words could. A participant noted, "An emoji doesn't always translate what you're feeling—it's easy to miss the tone behind it." Respondents also mentioned time zone differences, mismatched schedules, and the inability to gauge a partner's mood through a screen added further complexity to these emotional struggles.

Reimagining Connection

When envisioning what an ideal communication tool might look like, participants expressed a clear longing for technology that could mimic physical presence. In one of the open-ended prompts, I asked participants to imagine and describe—or even sketch—a tool or device that would help them feel closer to their partner while apart. Their responses revealed a consistent emotional thread: a desire for deeper, more embodied forms of connection. Many described features like haptic feedback, the sensation of a partner's heartbeat, shared warmth, or even soft tactile simulations that could replicate a gentle touch. These imagined tools weren't just about staying connected—they reflected a longing to feel the presence of a loved one in a more tangible, intimate way, reaching beyond what video and voice communication can offer.



Respondent 3 imagined a portal that could transport your hand back home

To investigate the feasibility of my future design concepts prior to real-world implementation, the second half of the questionnaire acted as an early-stage survey to test how my early design concepts (detailed below) might land. To do this I utilized multiple-choice and open-ended questions, focused on certain core ideas and themes from my designs. The approach allowed participants to envision new ideas—still in their conceptual phase—and offer feedback on perceived usefulness, emotional impact, and overall viability. Overall, the responses to these hypothetical scenarios were mixed, but they provided meaningful insights into what users genuinely crave in distanced communicating and connection. The feedback aided the development of future iterations.

Design Concepts

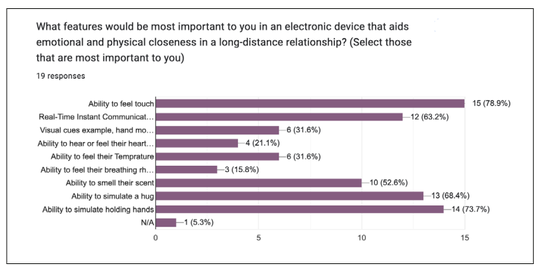
Huggables is a set of connected body pillows designed to simulate the comforting physical presence of a loved one from a distance. Each pillow is embedded with sensors that detect the user's heart rate, breath rate, and body temperature. This biometric data is transmitted in real time to the paired pillow, which responds by actuating gentle vibrations, rhythmic rise-and-fall motions, and warmth—mimicking the physical cues of the partner on the other end. This reciprocal interaction allows both users to send and receive real-time physical feedback, creating a shared tactile experience that softens the emotional weight of physical separation. The project explores how sensory technology can offer emotionally resonant alternatives for connection in long-distance relationships.

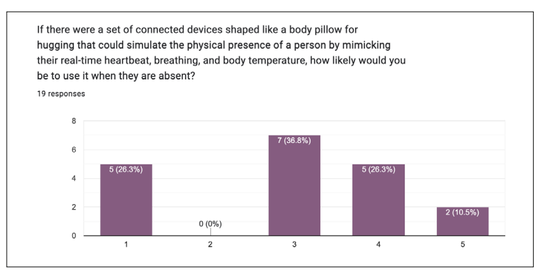
When introduced during the research phase, the concept drew a wide range of responses. Many participants described it as "soothing" and "emotionally grounding," appreciating the ability to exchange physical sensations—like the rhythm of a heartbeat or the warmth of a resting body—in real time. However, reactions were not unanimously positive. One participant referred to the idea as "a bit creepy," reflecting a discomfort with the intimacy of simulating presence through a non-living object.

Others expressed similar reservations about forming emotional attachments to an inanimate form.

Several respondents emphasized the importance of customizability—such as adjusting the intensity, timing, or even opting out of certain sensations—to help make the experience feel more personal and emotionally authentic. These mixed reactions underscored a key insight: designing for remote intimacy requires not just technological accuracy, but emotional sensitivity and room for individual boundaries.

Digital Embodiment is a kinetic art installation designed to simulate the presence of a loved one





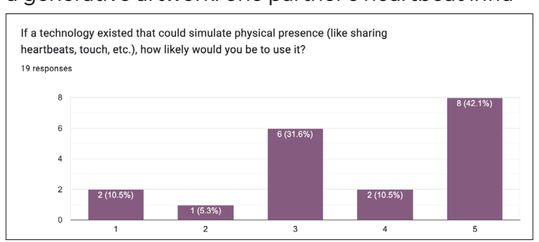
through subtle motion and symbolic visual cues. The piece consists of a modular structure embedded with actuated cubes that respond to real-time movement data captured from a remote user via an accelerometer. As the distant person moves through their space, the installation mirrors their activity through shifting, rhythmic movements—breaking the stillness of the structure in real time. The concept draws inspiration from heartbeat monitors, where the motion becomes a visual pulse—a sign of life, presence, and emotional energy occupying space even in absence.

When introduced to participants during my research, Digital Embodiment evoked mixed, sometimes polarized reactions. Those with a deep appreciation for art and aesthetics responded positively, describing the piece as "imaginative" and "visually calming." They envisioned it as something that could live in a shared space—like a bedroom or living room—serving as a gentle, poetic reminder of a loved one's presence. For them, the installation held potential not just as a tool for connection, but as a symbolic centerpiece that carried emotional weight.

Others, however, were less convinced of its value. Some participants questioned how relevant the installation would be in meeting their relationship needs, especially when compared to more tactile or wearable solutions. For individuals seeking direct interaction or physical feedback, the abstract nature of the installation felt secondary—more of an art piece than a communication tool. These responses revealed a meaningful divide between emotional symbolism and practical intimacy, underscoring the importance of offering a spectrum of sensory experiences to meet different kinds of connection.

In many ways, Digital Embodiment opened up a conversation about presence not through touch or voice, but through motion, symbolism, and atmosphere. It highlighted that not everyone connects in the same way—and that for some, the idea of feeling with someone might not always need to be felt on the body. Instead, presence could live quietly in the room, moving softly with the rhythm of someone far away.

Pulse Paint is a collaborative digital art experience designed to foster emotional connection between individuals separated by distance. The concept relies on biometric input—specifically real-time pulse readings—captured through sensors worn by each participant. These readings inform the behavior of a generative artwork: one partner's heartbeat influ-

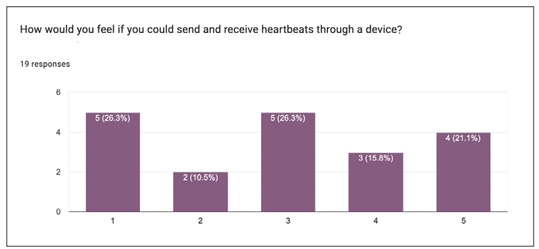


ences visual attributes like color or brush thickness, while the other affects the movement and speed of the strokes. The result is a shared digital canvas that evolves as both partners contribute their physiological rhythms to a single piece of art. It's less about the final painting, and more about the process—about feeling in sync, emotionally and bodily, through a nonverbal and creative medium.

Participants responded to Pulse Paint with enthusiasm, often describing the idea of "painting together" from afar as both "refreshing" and "surprisingly intimate." Unlike a video call, which tends to follow a conversational format, this project offered a shared, active experience—something that could unfold quietly and visually while still capturing presence and emotional state. Many appreciated how the visuals could reflect each person's inner tempo, offering a unique way to open up conversations around mood, mental state, or how they were feeling in that moment.However, not all feedback was entirely positive. While some participants raised thoughtful concerns about data privacy and the handling of sensitive biometric information, others questioned the emotional clarity of the visual output itself.

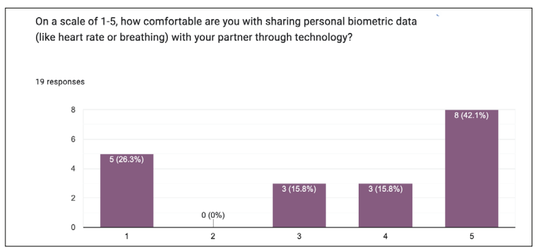
One participant noted that without context, the artwork might feel too abstract or ambiguous to clearly communicate what each person was feeling. This highlighted a potential challenge in balancing aesthetic openness with emotional legibility, especially in a system meant to foster understanding.

Despite these concerns, participants overwhelmingly viewed the concept as a playful and emotionally rich alternative to traditional modes of digital connection.



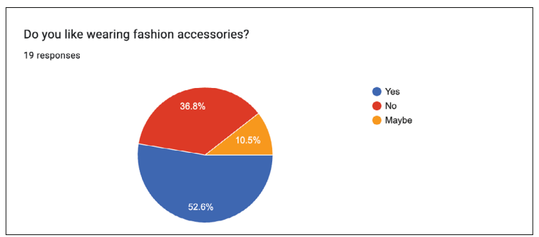
Challenges in Adoption and Ethical Considerations

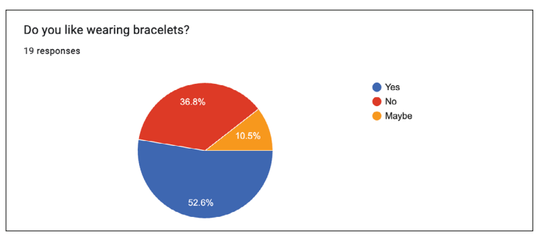
Despite the enthusiasm for these prototypes, several barriers to adoption were identified. Privacy emerged as a key concern, particularly with devices reliant on biometric data. Participants were cautious about how such sensitive information would be stored and used, calling for robust data protection measures. Another recurring concern was the potential over-reliance on these technologies, with some fearing that simulated interactions might diminish the value of real-life connections. Adapting to these tools was also seen as a potential challenge. The idea of deriving comfort from an inanimate object or a wearable device, while intriguing, would require a shift in perception and behavior. Several participants emphasized the importance of user education and thoughtful design to address these hesitations, ensuring that these technologies complement, rather than replace, human interactions.



Emerging Themes and Insights

Several overarching themes emerged from the data. Above all, participants overwhelmingly emphasized the importance of tangibility, citing tactile and multisensory elements—such as replicating touch, warmth, and other physical sensations—as critical for bridging the emotional gap in long-distance relationships. Equally significant was the need for customization, underscoring how personalized features can align with unique preferences and relationship dynamics. Respondents called for adjustable settings that fine-tune tactile intensity, along with visually expressive designs and modular functionalities that reflect individual styles. Finally, ethics and privacy proved central to user trust. As these technologies become more intimate, participants highlighted the necessity of transparency in data handling and robust security measures, advocating a balanced approach that embraces innovation while preserving the authenticity of real-world connections. Ultimately, the findings underscore a universal truth: no technology can fully replace the richness of human presence. Yet, by addressing the insights and aspirations shared in this research, we can create tools that bring us closer, offering a sense of warmth and connection in an increasingly digital world.





Secondary Research

Human Connection and Intimacy

Human connection is the invisible thread that weaves our inner world into the lives of others. It's not defined by proximity or constant interaction, but by the feeling of being truly known, felt, and received. It's the recognition that someone holds space for you—not just physically, but emotionally and energetically. This need to connect is as essential as food or shelter. From our earliest moments, we search for it in the gaze of our caregivers, in the warmth of touch, in the sound of a familiar voice. It roots us, orients us, and affirms that we exist in relation to something larger than ourselves.

As Yuval Noah Harari explains in *Sapiens: A Brief History of Humankind*, the ability to form close, trusting social bonds was not just emotionally fulfilling—it was a key factor in the survival and success of early Homo sapiens. Our ancestors evolved in complex social groups where cooperation, empathy, and connection offered a tangible advantage. Those who could build relationships, read emotional cues, and maintain alliances were more likely to survive threats, raise children, share resources, and transmit knowledge across generations. Harari argues that it was our capacity for storytelling, gossip, and social bonding that allowed early humans to organize themselves in larger groups than other species—ultimately helping us outcompete other hominins like Neanderthals (Harari 25–27). In this light, connection is not just a cultural ideal or emotional luxury—it's a biological imperative. We're hardwired for proximity, mutual recognition, and emotional attunement. Social bonding isn't something that comes after safety and survival; it is part of how we survive. This deeply embedded need for connection helps explain why the absence of physical presence—especially in long-distance relationships—can feel so destabilizing. It also highlights the potential power of emotionally intelligent technologies to simulate closeness, offer comfort, and sustain relationships in the absence of physical touch. Understanding our evolutionary reliance on connection reframes intimacy not as a soft concept, but as a foundational element of human resilience.

These aren't abstract ideals—they're survival-level priorities. Connection, in this framework, isn't a luxury—it's a basic requirement of a healthy, whole life. When it's missing, something fundamental inside us begins to fray. As we move through life, connection becomes the foundation of belonging. In their book *Attachment in Adulthood: Structure, Dynamics, and Change*, psychologists Phillip R. Shaver and Mario Mikulincer discuss the psychology of attachment, emphasizing that our earliest bonds—formed through touch, responsiveness, and emotional attunement—lay the groundwork for how we relate to others throughout our lives. They write, "Attachment is a basic human need, beginning in infancy and extending throughout the lifespan, profoundly influencing our emotional well-being, stress regulation, and capacity for intimacy" (Mikulincer and Shaver 5). From birth, secure attachment helps us build trust and resilience, while disruptions in connection can lead to difficulties in emotional regulation and relationship dynamics later in life. It exists in friendships that offer safety, in partnerships that offer depth, and in communities that hold shared meaning. We rely on it to soften the weight of solitude, to ground us during moments of change, and to celebrate what is joyful. Connection does not always announce itself loudly. Often, it lives in the quiet rituals we come to depend on—the way someone looks at us when we enter a room, the comfort of a shared routine, the weight of a hand placed gently on our back. These are not grand gestures. They are the everyday echoes of care and recognition that hold us steady in the chaos of the world.

Intimacy lives within these connections. It's the slow unfolding that happens when we allow ourselves to be seen without the armor. It's often not built through grand expressions, but through the accumulation of small moments: honesty offered without expectation, tenderness given without transaction. It asks for presence, for softness, and for the kind of attention that doesn't flinch in the face of vulnerability. In her book *Daring Greatly*, researcher Brené Brown defines vulnerability as "uncertainty, risk, and emotional exposure," and argues that it is not weakness, but rather the birthplace of love, belonging, joy, and empathy (Brown 34). She writes, "Vulnerability is the core, the heart, the center of meaningful human experiences" (Brown 12). In other words, the ability to show up fully—without armor—is what makes real connection possible. In the context of long-distance relationships, where so much communication is filtered and curated, designing for intimacy must also mean making space for imperfection, emotion, and the quiet bravery of being seen. Intimacy is not exclusive to romantic relationships. It is present in the way a friend remembers your favorite song, in the way a parent instinctively knows when something is wrong, in the way silence can stretch between two people and still feel full.

The experience of intimacy is not solely emotional—it's also sensory. It is communicated through the warmth of a body near yours, the smell of a loved one's skin, the cadence of a laugh you can recognize in a crowded room. Our senses are the first language we use to navigate the world and the last we forget. From infancy, we learn about safety, comfort, and connection not through words, but through touch, sound, warmth, and rhythm. Developmental psychologist D.W. Winnicott emphasized the importance of early sensory experiences in forming secure attachment, particularly the "holding environment" created through touch and physical presence. These early interactions lay the foundation for how we understand closeness and regulate emotion throughout our lives. (Winnicott 45)

Research from Harvard Medical School also reinforces the enduring role of the senses, particularly touch, in shaping cognition and emotional well-being. As noted in their 2022 article *Exploring Our Sense of Touch from Every Angle*, sensory input—especially through the skin—plays a vital role in social bonding and brain development, beginning in infancy and continuing throughout life. Tactile experiences like holding hands, hugging, or being held activate neural pathways associated with trust and emotional regulation. These findings reveal that sensory communication isn't just supplementary—it is fundamental. Our bodies remember before our minds do. Engaging the senses through texture, temperature, sound, and rhythm allows us to access emotional memory in ways that language often cannot. In the context of long-distance relationships, where verbal and visual channels dominate, designing for sensory engagement becomes a way to restore emotional depth—to speak to the body, not just the screen.

When someone is absent, it's these textures we ache for—not just their presence, but the way their presence feels. In physical closeness, intimacy isn't guaranteed—but the conditions to nurture it are more naturally present. It's possible to be in the same room and still feel distant. Yet, when touch, shared rhythm, and subtle cues align, physical presence often provides a fuller, more embodied language of connection—one that can be harder to replicate from afar. When space intervenes, when life pulls us across time zones and oceans, we begin to understand just how deeply intimacy relies on these subtle, multisensory cues. Physical touch has been shown to trigger hormonal and neurochemical changes that directly impact emotional well-being. Research has consistently demonstrated that affectionate touch stimulates the release of oxytocin, often called the "bonding hormone," which enhances feelings of trust, attachment, and security. It also reduces levels of cortisol, the stress hormone, thereby lowering anxiety and promoting a sense of calm. According to Uvnäs-Moberg et al., these physiological responses are not only emotionally comforting but also contribute to long-term physical health by regulating heart rate and blood pressure (Uvnäs-Moberg et al. 3).

Beyond touch, other sensory cues—such as voice tone, facial expression, and shared rhythm—further reinforce emotional bonding. These nonverbal forms of communication activate the brain's limbic system, which processes emotion, suggesting that connection is not purely intellectual or verbal—it is fundamentally embodied. In the absence of the body, connection becomes a design challenge. It becomes something we must rebuild intentionally, through language, through symbols, through rituals that mimic the physical closeness we no longer have. We lean on memory, technology, and creativity to keep a relationship alive—not out of obligation, but out of longing. In these moments, intimacy becomes a form of architecture. Every message, every shared playlist, every video call, every object infused with scent or sound—these are the materials. And through them, we construct a version of presence that, while different, is no less meaningful. Connection and intimacy are always vital but can feel even more vital when you are apart from a loved one.

What Fosters Connection and Intimacy?

Finding connections can happen spontaneously. You may suddenly discover a shared love of an old tv show in conversation with an acquaintance. This is an instance of someone connecting with another through verbal conversation. That can happen in person, but it can happen in a digital space, like texting, a video call, even an online forum. But connection and intimacy can also take effort and thought, especially in long distance relationships. In these situations, connection and intimacy need to be nurtured and maintained.

At the heart of connection and intimacy is communication. It is the medium through which care is expressed, trust can be formed, and emotional safety found. Communication is not simply the exchange of words. It is a combination of a wide variety of human actions and experiences. Gesture, tone, memory and intention, for example, are all a part of communication. And we speak to one another in many ways—through voice, touch, image, eye contact—even silence can speak volumes. Whether in shared space or stretched across distance, our communication creates the foundation of our relationships, as well as how they grow. In my work, I look at communication through two lenses: verbal and nonverbal. Verbal communication includes both spoken and written language—tools we use to articulate thought, emotion, and intention. But verbal exchanges alone are rarely enough. Michael Argyle notes in *The Psychology of Interpersonal Behaviors*, up to two-thirds of communication in personal interactions is conveyed through nonverbal cues, like body posture, eye contact, tone, facial expression, timing, and spatial distance (Argyle 93). These cues often operate beneath the consciousness, yet they carry the emotional weight of the message. A slight pause, a shift in tone, a turned shoulder—all of these inform how we interpret meaning and feel understood (Argyle).

In relationships where individuals can interact in person, these cues are naturally present, embedded in everyday interactions. A partner's sigh, a smile, the brush of hands during a conversation—these are signals of attention, engagement, and care. But in long-distance relationships, where you cannot be physically present, these kinds of signals are muted or lost entirely. The absence of touch and subtle physical interaction reshapes how intimacy is expressed and received. Scientific research supports the importance of nonverbal communication in fostering intimacy and trust. In their book *Nonverbal Communication in Human Interaction*, Judith A. Hall and Mark L. Knapp demonstrate that nonver-

bal cues—such as eye contact, posture, touch, and facial expressions—play a central role in regulating conversations, expressing emotions, and building relational closeness. For example, they describe how behaviors like leaning forward, maintaining appropriate eye contact, or mirroring another's body language can signal attention and emotional availability, thereby fostering what they term "immediacy." In this context, immediacy refers to the use of nonverbal behaviors to reduce psychological distance and enhance interpersonal closeness—something verbal communication often does more slowly or indirectly (Knapp and Hall 34).

These nonverbal cues provide instant, intuitive feedback that helps people feel seen, understood, and emotionally connected in real time. This immediacy—the sensation of closeness or emotional proximity—is crucial for sustaining intimacy, particularly when partners are physically apart. Knapp and Hall also note in their work that verbal messages become more emotionally potent when supported by nonverbal cues such as warmth in tone or meaningful gestures. They point to examples like a comforting phrase delivered with a gentle voice and open posture, which is far more effective in conveying empathy than the same words spoken in a flat tone. This synchronization of layers—speech, sound, rhythm, facial expression, and gesture—creates a multimodal experience that resonates not just cognitively, but physically and emotionally, engaging the listener's full sensory awareness (Knapp and Hall). Human communication is deeply embodied. We do not just understand others through words—we feel them. Someone's scent, the softness of the clothing they're wearing, the weight of their hand in ours—these are sensory cues that carry unspoken emotional messages to the brain. Sensory perception plays a critical role in how we form and store emotional memory. Cognitive neuroscientists Shams and Seitz found that multisensory input leads to significantly stronger memory encoding and emotional association. Their research showed that when multiple senses are engaged simultaneously, the brain forms more robust and lasting memories than when relying on a single sensory input alone (Shams and Seitz 93). When more of the body is involved in the moment, the memory becomes richer, more resilient, and more emotionally tethered.

This is where multisensory communication becomes more than a concept—it becomes a practice of emotional sustainability: the ability to preserve emotional closeness and well-being through sensory and symbolic experiences when physical presence isn't possible. Memory is not only cognitive; it is also deeply sensory. According to Herz and Engen, olfactory input—what we smell—has "privileged access to the amygdala and hippocampus," the brain regions tied most directly to emotion and memory (Herz and Engen 300). But it's not just scent. Visual and auditory cues also play a significant role. For instance, pairing images with congruent sounds enhances memory retention, as the integration of these senses creates a more cohesive and memorable experience (Shams and Seitz 93). The texture of a loved one's t-shirt, the rhythm of their voice, or the way light fell in a shared space—these embodied memories can act as portals, transporting us back into moments of connection. This kind of memory—rooted in the senses—offers a powerful gateway to reconnection, helping us sustain emotional bonds even when we are apart.

This is why physical tokens—an article of clothing, a handwritten letter, a sound clip of a laugh—become deeply important in long-distance relationships. They are not just sentimental objects; they are sensory portals. Neuroscientific studies show that reactivating sensory experiences associated with emotional closeness can ease the stress of separation and reinforce emotional bonds over time. For example, Janata et al. (2012) studied how autobiographical memories triggered by music activate brain regions associated with emotion, memory, and social connection. Using fMRI scans, they found that familiar songs could evoke vivid personal memories—especially those linked to relationships—and that this sensory reactivation created a measurable feeling of emotional closeness, even when the person connected to that memory wasn't physically present (Janata et al. 1803).

In this way, multisensory communication doesn't just help maintain connection—it helps repair it by reigniting feelings of closeness that may have faded and renews it by offering a fresh emotional reminder of love and presence. In simple terms, it's like emotionally reaching out through the senses: when we hear a loved one's laugh or hold something that once belonged to them, we're not just remembering them—we're feeling with them again. In long-distance dynamics, where sensory communication is limited by the lack of physical presence and touch, communication becomes a creative act in a way. You must create or re-create your presence on a sensory level. For example, voice notes carry the tone and cadence of your voice. Scent-infused letters or objects hold memory. Simulated heartbeat devices offer a rhythmic reminder of life on the other side of the world. These adaptations represent more than technological convenience—they are emotional strategies for preserving connection in the absence of presence. In this way, multisensory communication becomes a bridge, allowing love and presence to take shape in new forms.

Modern Communication Technology

Modern communication technology can connect people across distances in ways we could not just a few decades ago. From Alexander Graham Bell's invention of the telephone patented on March 7, 1876, which for the first time allowed real-time conversations across vast distances, to today's smartphones, video calls, social media, and virtual reality, our world continually reshapes itself around tools intended to foster closeness. But does it deliver?

In many ways, these tools have reshaped experiences of connection, intimacy and communication. They offer new ways of feeling emotionally close, through instant sharing, constant contact, and some sort of presence, despite physical absence. However, this same immediacy has reshaped expectations, often diluting emotional depth by promoting rapid, surface-level exchanges. We can speak to anyone at any moment, but many of us know that simply having the tool— like an iphone, does not directly lead to meaningful communication.

Author Nancy Baym emphasizes this paradox in her book *Personal Connections in the Digital Age*. She highlights that while digital platforms like social media and messaging apps increase connectivity, they also fragment attention, diminishing meaningful interpersonal engagement (Baym 98). As she notes, "The same media that bring us closer to some people can distance us from others and even from ourselves, by encouraging a perpetual state of distraction and divided attention" (Baym 98). This creates interactions that can feel emotionally shallow, marked by distraction rather than genuine intimacy.

The COVID-19 pandemic significantly amplified the emotional impact of physical separation, reshaping how we rely on communication technologies. While many of the tools—such as video chatting—already existed, their role shifted from casual convenience to emotional necessity. Millions were suddenly dependent on these platforms to maintain relationships, process grief, celebrate milestones, or simply feel less alone. Platforms like Zoom responded by quickly introducing features such as virtual backgrounds, breakout rooms, and enhanced stability to accommodate everything from family reunions to weddings, classrooms, and support groups. One of the most profound shifts occurred in the mental



Group Video Call On Zoom Source: Zoom.com

health industry, where in-person therapy rapidly transitioned to teletherapy. Practitioners and patients alike adapted to meeting through screens, transforming a deeply personal and emotionally intimate experience into a digital one. For many, it was their only option. This shift not only normalized remote emotional support but also highlighted both the possibilities and limitations of technology in spaces built on connection and healing.

In long-distance relationships, where you are dependent on tools like iphones and computers to communicate with loved ones, the limitations and the potential of this kind of technology become particularly clear. Video calls through platforms like Zoom or FaceTime provide real-time visual and auditory presence. You can see someone's expression, hear the tone of their voice, and see gestures they make—if they are in view of the camera.



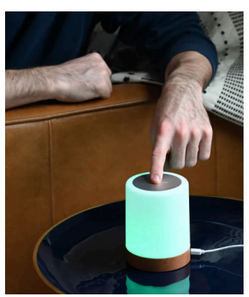
Bond Touch & Heart Source: bond-touch.com

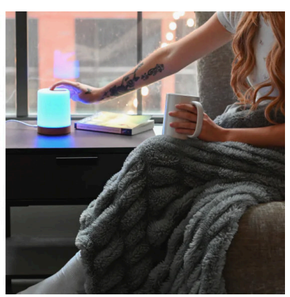
In long-distance relationships, video chatting often becomes the primary means of maintaining connection—provided both partners have access to the necessary technology. These tools can go a long way in sustaining communication and emotional closeness. However, they fall short of replicating the full spectrum of multisensory interaction that exists in physical presence. What's lost are not just casual touch or shared rituals, but the biological and emotional benefits that come with them. Human touch triggers the release of oxytocin—a hormone linked to stress reduction, emotional bonding, and overall well-being (Uvnäs-Moberg et al.). In its absence, the subtle regulation of mood and closeness that happens through touch is diminished. Just as significantly, remote communication often lacks shared environmental context and the spontaneity of genuine co-presence—qualities that are frequently replaced by more structured, formalized, and cognitively demanding interactions (Olson and Olson). These gaps make it difficult to recreate the natural ease of simply being together.

In her book *Hold Me Tight: Seven Conversations for a Lifetime of Love*, Dr. Sue Johnson emphasizes that emotional connection goes beyond visuals or voice, writing, "It is not just the words or even the tone of voice that matters but the emotional music behind the words—the emotional signals that show we are in tune" (Johnson 91). This kind of emotional attunement requires synchronous emotional and sensory feedback—areas where video calls still fall short.

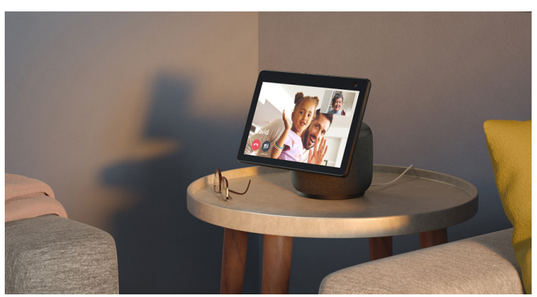
Multimodal communication, engaging multiple senses simultaneously, has attempted to bridge these gaps. Products like the Bond Touch bracelet and the Bond Heart Necklace are an example of technology being used to simulate presence through sensation and biological rhythm. The bracelet allows partners to exchange gentle vibrations that mimic a real-time touch, while the necklace captures and stores a loved one's heartbeat, replaying it vibrationally, on command, as a rhythmic memory. These devices are an attempt to provide a sort of sensory reassurance and togetherness. They create rituals of connection that could feel intimate. Research by Morrison et al. (2016) demonstrated that simulated tactile experiences can significantly enhance feelings of intimacy, emotional warmth, and connection even in digital contexts. In their study, participants experienced affective touch via a soft brush applied to the skin at specific speeds while viewing emotionally evocative images or receiving affectionate messages. This combination of gentle, slow stroking and emotionally relevant stimuli was shown to activate the brain's social bonding systems, significantly increasing participants' reported feelings of emotional closeness and warmth (Morrison et al. 521).

Every day, more and more multisensory communication technology tools pop up, to create remote, nonverbal cues. Friendship Lamps, created by Luvlink, are another example of this. When one person touches their friendship lamp, its counterpart lights up. It's a silent, spontaneous signal of presence, shared through light. These nonverbal gestures, while simple, can carry emotional weight. They offer a tangible, almost poetic way to communicate, as well as sustain intimacy and closeness over distances.





LuvLink Lamps Source: Luvlink.com



Amazon Echo Show 10-Picture Source: pcmag.com

Another product in the realm of multisensory communication tools, is the Amazon Echo Show. It utilizes an integrated tracking feature. The Echo Show, particularly the models equipped with smart motion features, dynamically tracks a user's movement during video calls using a combination of visual recognition and motorized hardware. A built-in camera paired with computer vision technology detects where the user is in the room, and the device's display subtly pans, tilts, or zooms to keep the user centered in the frame. This allows the device to maintain eye contact and visual continuity even as the person shifts position—whether they're pacing, sitting down, or moving around during a conversation.What makes this subtle interaction meaningful is the way it mirrors the natural rhythm of shared physical space. Instead of freezing the person in a static frame, the Echo Show adjusts in real time, allowing for a more fluid and attentive presence. This sense of being "followed" by the camera creates a soft illusion of physical attunement, enhancing emotional connection and reducing the friction of remote communication. It transforms the video call from a fixed window into a more responsive and human-feeling interaction—one that mimics the way we intuitively orient ourselves toward each other in person.



Apple Vision Pro Source: Apple.com

Another huge development in remote communication and connection, is mediated presence. "The mediated sense of presence is a technology-induced illusion of being present in one (simulated) place when one is actually present in another (physical) place" (Gorini et al)." Platforms incorporating mediated presence, such as virtual reality (VR) and augmented reality (AR), promise a more immersive experience. VR headsets like Meta Quest and Apple Vision Pro create simulated, shared environments that foster a strong sense of presence—allowing two people to feel as though they're occupying the same virtual space. In VR, users are visually and aurally immersed; they can look around, hear sounds positioned all around them, and interact with the environment. While objects can be virtually "touched," this is typically achieved through controllers using pointing and clicking mechanisms.

Apple Vision Pro advances this experience further by combining dynamic sound positioning with body-driven interactive elements. Its audio system tracks head movement and environmental cues to make digital conversations and media feel anchored in space—so if someone appears to your left in a FaceTime call, their voice will sound like it's coming from that direction. Paired with gesture-based controls, eye tracking, and voice input, the headset allows users to interact with content naturally—simply by looking and making small hand movements. These features significantly enrich sensory engagement and emotional immersion, making digital presence feel more embodied and intuitive. The Disney VR holotile prototype enables users to walk physically within virtual spaces, introducing embodied motion that reinforces presence and reduces dissonance between perception and body movement. Unlike traditional VR setups, where users navigate using joystick or teleportation-style mechanics that can feel disconnected from real-world physicality, this omnidirectional treadmill allows users to move naturally in any direction—forward, backward, sideways, or in circles—while remaining in a fixed physical location.



Disney Holotile-Picture Source: mixed-news.com

The system works through a combination of a low-friction, multi-directional surface and motorized belts that respond in real time to the user's walking direction and speed. As users begin to walk, the treadmill counteracts their movement to keep them centered on the platform, while VR visuals adapt accordingly, creating the illusion that they are walking freely through a digital environment. Integrated sensors track foot placement, stride, and body orientation, allowing the virtual world to respond seamlessly to even subtle shifts in posture or direction. This makes the experience feel more intuitive and embodied, as if the user's physical body is "inside" the virtual space.



Source: gamescent.com

By enabling natural locomotion, the Disney treadmill reduces the cognitive dissonance often associated with VR navigation—where your eyes perceive movement, but your body remains stationary. This alignment between physical and virtual motion enhances spatial presence, allowing users to feel more grounded and connected to their environment. When combined with social VR experiences, these locomotion-enhanced environments help foster more authentic shared experiences, as users can walk together, gesture, and move in ways that mirror real-life interactions.

Another major development in this arena of technology comes from olfactory design—design focused on scent and smell. The GameScent AI-powered diffuser analyzes real-time audio from games and virtual environments to release contextual scents—such as the smell of a forest, fire, or food—intensifying emotional immersion. Since scent is directly linked to the brain's limbic system, responsible for memory and emotional processing, GameScent adds another channel for emotional closeness. Smells tied to memory or intimacy—like a partner's perfume or the scent of a favorite shared meal—can be reintroduced into a digital context to strengthen presence and emotional recall (GameScent).



Haptic Jacket Source: bhaptics.com

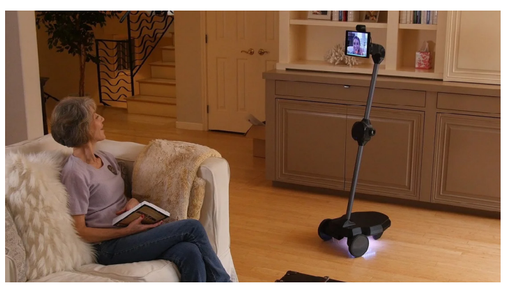
Complementing scent-based immersion is the bHaptics TactSuit, a full-body haptic feedback vest designed for VR gaming and interactive experiences. The suit contains an array of vibration motors strategically placed across the chest, back, arms, and face, which respond to in-game stimuli in real time. This allows users to physically feel virtual events—whether it's the recoil of a weapon, the impact of rain, or the sensation of being touched by another avatar. By translating digital information into physical sensation, the TactSuit enhances embodied presence and contributes to a richer emotional engagement. In emotionally resonant contexts like long-distance experiences or narrative-driven environments, this tactile layer becomes more than gameplay—it becomes emotional infrastructure, helping users feel not just seen or heard, but touched.

Roy Ascott, a foundational thinker in telematic art and human-machine interaction, offers an important theoretical lens to understand these immersive experiences. He refers to such technologically me-

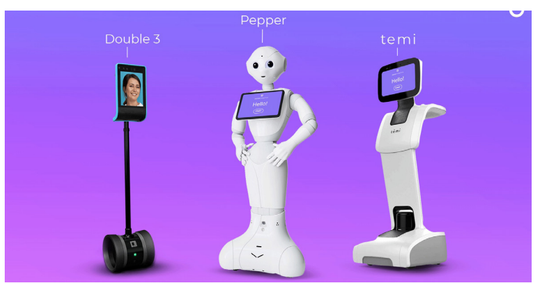
diated states as part of the “telematic embrace,” where presence is not about physical co-location but a shared field of interaction. He writes, “Telematic art challenges the notion of fixed reality by presenting a world that is dynamically constructed by the interaction between participants and their technologies” (Ascott 232). For Ascott, presence is not simply simulated—it is actively co-created through behavior and feedback. “The medium is no longer a surface or a screen—it is a behavior, a condition, a process” (Ascott 72).

His perspective resonates deeply with immersive technologies like VR, where users don’t passively observe—they enact and shape the experience. In this light, technologies such as the Apple Vision Pro, Disney’s omnidirectional treadmill, GameScent, or the bHaptics suit are not just tools of simulation, but arenas of emotional and perceptual participation, creating a space in which digital presence becomes intuitive, embodied, and shared. Telepresence robotics is another field attempting to simulate presence. Telepresence robots are robots someone can control. They are connected to the internet, and can act as your eyes and ears in a location you are not present in. Devices like the Ohmni Telepresence Robot and Double 3 by Double Robotics allow users to “move” within another space remotely attending family gatherings, visiting shared spaces, or simply being seen wandering the hallways of a home. These robots offer mobility when you are still, real-time video, and self-driving features.

Alongside these interfaces are more intimate gadgets designed specifically for long-distance couples. Connected sex toys by companies like Lovense, We-Vibe, and OhMiBod offer synchronized pleasure across distances. These devices use Wi-Fi or Bluetooth to transmit sensations between partners in real-time, blending intimacy with techno-



Ohmni Telepresence Robot Source: gearbrain.com



Telepresence Robots Source: provenrobotics.ai

logical sophistication. Some models even integrate voice, touch, or video call syncing, helping maintain physical connection where presence is not possible. Digital tools, despite their breadth, have the potential to flatten emotional nuance, limiting our ability to perceive tone, intent, or subtle shifts in mood, or attitude that we can sometimes pick up more easily in person. Current and emerging communication technologies hold promise in increasing connection, but they have drawbacks as well. Regardless, tools like iPhone and computers have become our bridges across geographical divides, our comfort during isolation, and the tools of expression we use in long distance communication.

But the ability to share information instantly or speak to one another in real-time does not necessarily foster the intimacy we crave. We live in an interesting time. The COVID-19 pandemic, in many ways, pushed these technologies into our daily lives. The question that remains is whether they can continue evolving—not just in function, but in feeling.

Artists, Designers and Technologists Who Explore Long Distance Relationships

Many artists focus on the dynamics. In developing my own thesis projects, I have been particularly influenced by artists and designers who explore presence, intimacy, and communication in both physical and speculative ways. A major influence on my work is Rafael Lozano-Hemmer, particularly his installation Pulse Room (2006). In this piece, participants hold a sensor that records their heartbeat, which is then translated into a flickering light bulb. As more people engage, the room fills with light, each one echoing the rhythm of somebody once present in the space.

The installation feels like an archive of presence. This piece resonated with me because it visualizes the unseen, turning something as intimate and embodied as a heartbeat into a shared experience. The piece could be looked at as very simple in that the artist just uses a lightbulb to represent the data. But, despite that simplicity, it captures something complex. Inspired by this, I’ve embedded biometric data—specifically heartbeats and motion—into my own work, not just as input, but as symbolic material that carries memory, presence, and emotion across time and space.

Distance Lab’s Mutsugoto (2008), a research-driven installation, allowed partners in different rooms to draw on each other’s bodies using light projections. The piece used touch interfaces and ambient visual feedback to explore intimacy beyond screens. What moved me was its softness—it didn’t try to simulate touch with perfect realism, or haptic vibration, but instead introduced a poetic alternative—glowing lines. It created a gesture-based conversation, a new language. This reimagining of physicality is

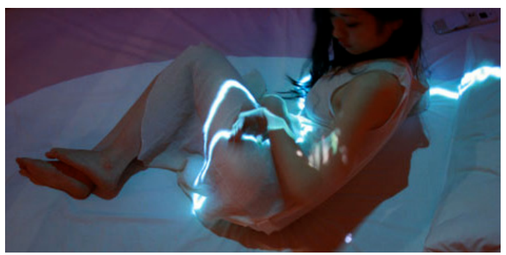
what led me to explore what I call sensory metaphor. In my work I am not trying to recreate physical closeness as it exists, but to evoke it symbolically—through motion, texture, and synchronized gesture.

Miranda July's interactive app project Somebody (2014) also shaped my design thinking in an unexpected way. This project allowed users to send a message to a loved one through a stranger, who would physically deliver the message in person—an odd, beautiful disruption in sender and receiver. July's work confronts the awkwardness of mediated communication and leans into it rather than smoothing it out.

It helped me realize that intimacy can live in strangeness, imperfection, and the unexpected. I took this insight into how I designed user interactions within my own pieces—allowing space for subtle delays, emotional ambiguity, and reflective pauses rather than constant responsiveness. The technology in my work is expressive but never polished to a point of perfection or homogeneity. Like July's app, I'm more interested in making people feel than simply facilitating contact.



Pulse Room (2006)





Distance Lab's Mutsugoto (2008)

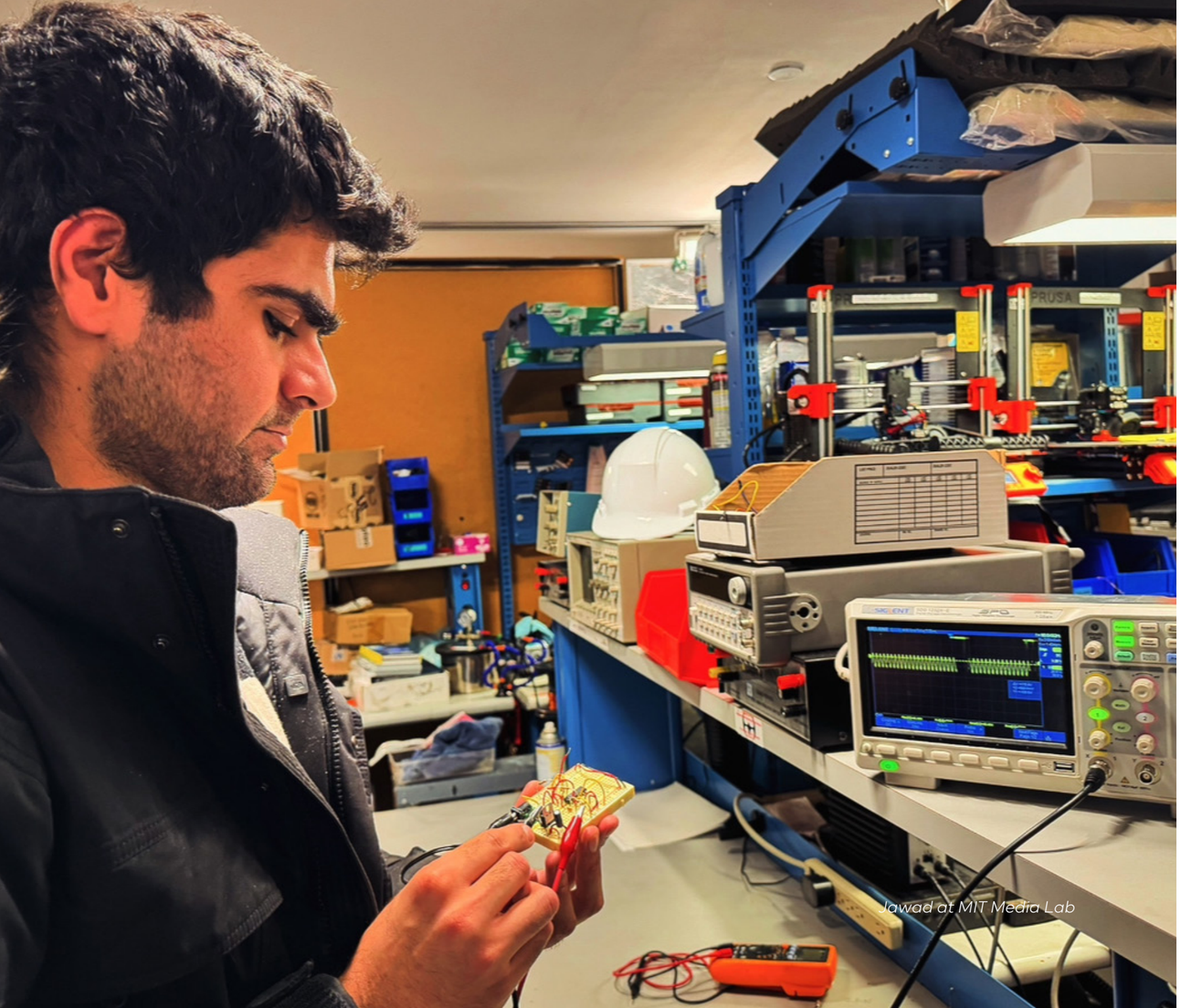
Media Lab Encounters: A Tangible Vision of Intimacy

I took a crossover class at the MIT Media Lab titled Sensor Technologies for Interactive Environments, offered through the Responsive Environments Group. This class was fundamental to the projects you'll read about later in this book. It not only sharpened my technical sensibility but also exposed me to the human-centered innovation within the Lab. During this time, I discovered the Tangible Media Group, led by Professor Hiroshi Ishii, whose work has deeply influenced how I think about presence, embodiment, and sensory feedback.

The Tangible Media Group explores how digital information can be given a physical body—shifting interaction away from screens and toward physical space. Their philosophy, Radical Atoms, imagines a future where data isn't just visualized but touched, felt, and physically manipulated. This philosophy is strongly represented in my thesis, which focuses on transforming human data, like heartbeats and movement into tactile, poetic experiences of presence. One of their early and iconic pieces, the Hugging Jacket (Like-a-Hug), is a puffy wearable that inflates and gently squeezes the wearer when someone likes their post on social media. While lighthearted, the piece reflects something deeper—how digital gestures of care can be embodied, turning feedback into physical affection. It also makes data uniquely human. It's a friendly form of subversion. This piece aligns with my goal of giving form and weight to presence across distance.

Projects like inFORM, a dynamic shape display developed in collaboration with the Changing Places group, made a particularly lasting impression on me. It consists of a grid of physical pins that rise and fall in real time, forming three-dimensional shapes controlled remotely. When a person interacts with the system from a distance—say, moving their hand over a sensor—those movements are mirrored on the display, physically sculpting the pins into corresponding contours. It's not just data visualized—its presence given form. Watching it move feels like watching someone press their hand through the surface of a table from another room, another city, another life.

Transform, a follow-up installation, evolves this idea from interaction to emotion. It uses the same pin-based mechanism but shifts the focus from remote control to ambient choreography. The surface ripples, pulses, and undulates in sync with environmental input—such as sound, air, or time—transforming raw data into a performance of form. Rather than prompting interaction, it invites reflection. Motion becomes meditative. These pieces helped me reimagine motion not as utilitarian output but as emotional gesture—something capable of suggesting presence, memory, and shared ritual.



Jawad at MIT Media Lab

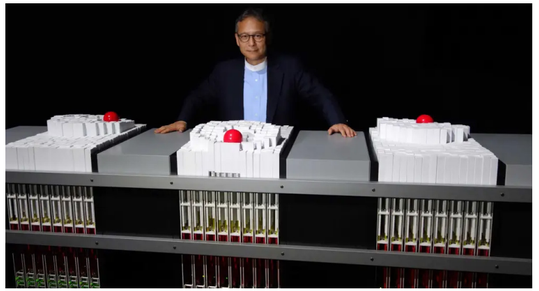
Beyond these large installations, several smaller, more intimate projects deeply resonate with my design lens. InTouch explores how pairs of mechanical rollers—physically linked across distance—can mimic the sensation of turning and holding a shared object, simulating touch and collaboration.

LumiTouch consists of paired picture frames that respond to a user's touch by illuminating and emitting warmth on the partner's frame, turning a photograph into a live emotional interface.

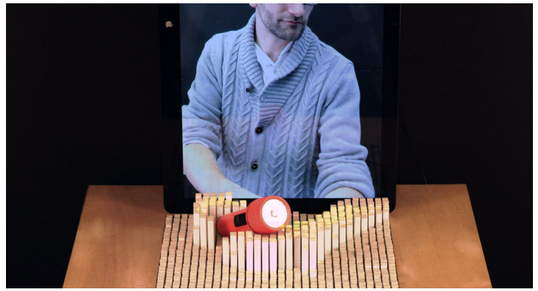
Ambient Room further expands this vision by embedding ambient media—light, sound, airflow, and kinetic objects—into a room's architecture, subtly conveying digital information through physical atmosphere. It offers a more emotional approach to peripheral awareness, creating calm technologies that inform without interrupting.

I was also drawn to Ambient Fixtures, which explore how objects in everyday environments can reflect the passage of time or presence through subtle movement and color. These projects demonstrate how design can blend seamlessly into our lived space, while still communicating deeply.

What inspired me most was not just the technology itself, but the intention behind it. Ishii's group treats intimacy, play, and emotion not as extras but as core components of human-computer interaction. They envision a world where data is not distant or abstract, but visceral and embedded in our material realities. That ethos mirrored what I was building tools that don't just deliver messages but allow people to feel each other again.This encounter with the Media Lab helped me see that the emotional



Transform Table Source: MIT Media Lab



inFORM Source: MIT Media Lab

and technical don't have to be separate. They can work together—where motion becomes metaphor, and code becomes care. That realization helped carry my projects forward, and shaped how I approached building prototypes, sensors, and poetic functionality into the work you'll explore in the coming chapters.



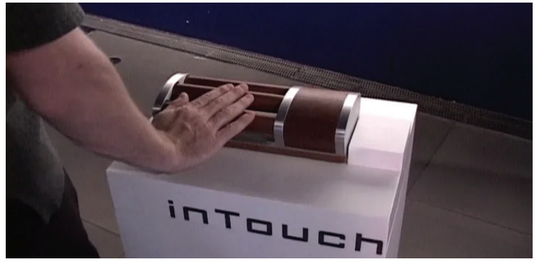
Ambient fixtures Source: MIT Media Lab



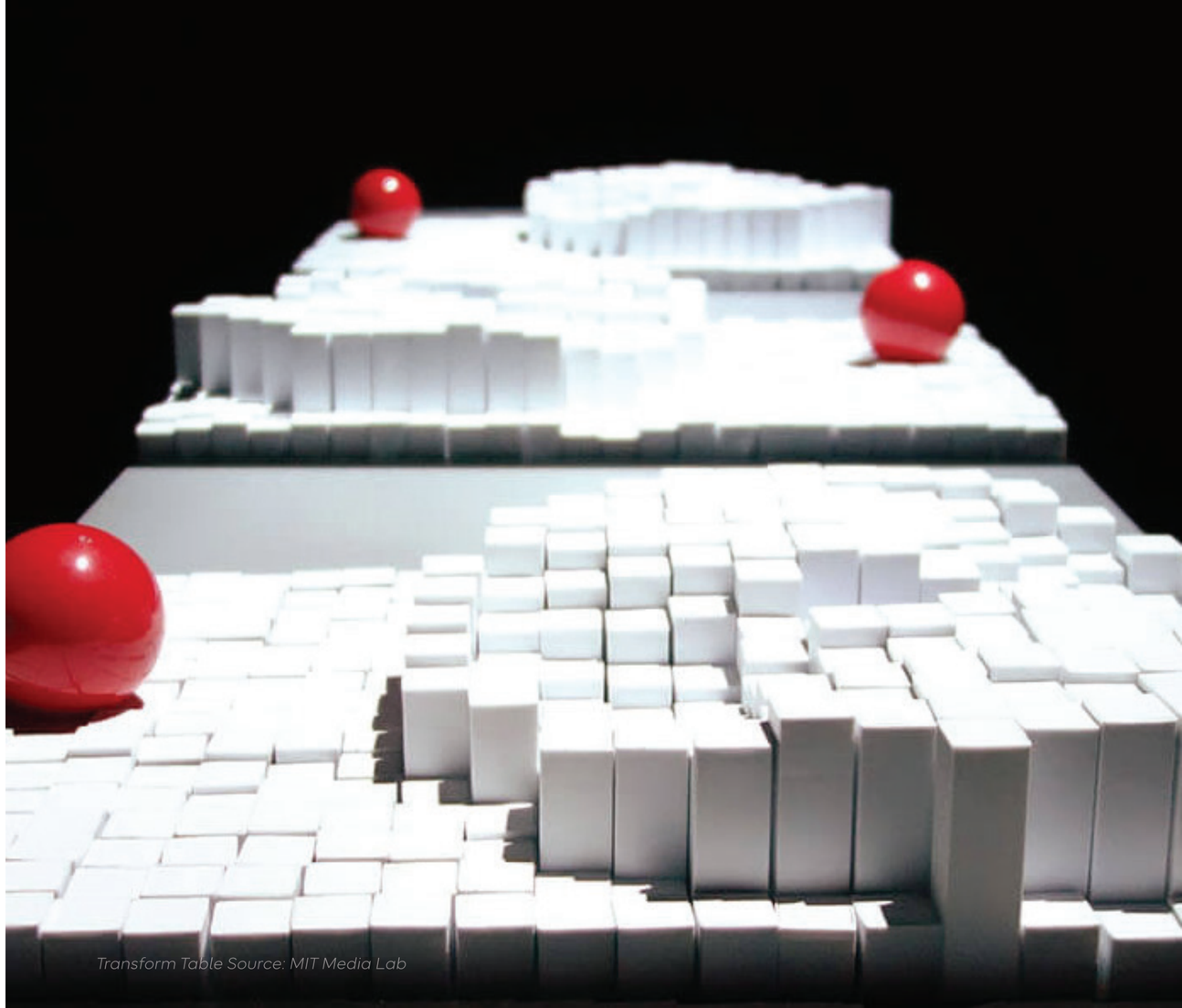
Ambient room Source: MIT Media Lab



Lumitouch Source: MIT Media Lab



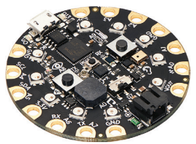
inTouch Source: MIT Media Lab



Transform Table Source: MIT Media Lab

Case Studies

Project Components Glossary



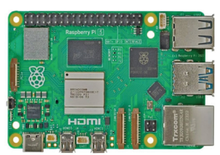
Circuit Playground Express is a SAMD21 microcontroller board with built-in sensors, NeoPixels, buttons, and a speaker—programmable via CircuitPython, MakeCode, or Arduino.



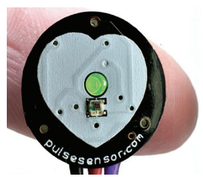
Arduino Uno R4 is the latest 5 V Uno board featuring a faster 32-bit ARM Cortex-M4 MCU, USB-C connectivity, and full R3 shield compatibility—programmable via the Arduino IDE.



ESP32-C6 is an Espressif microcontroller SoC with Wi-Fi 6, Bluetooth 5 LE, and IEEE 802.15.4 radios for secure, low-power IoT applications.



Raspberry Pi is a credit-card–sized Linux single-board computer with HDMI, USB, wireless, and GPIO pins for DIY and educational projects.



Pulse Sensor is an optical heart-rate sensor (a photoplethysmograph) that clips to your skin and outputs an analog pulse waveform for microcontroller projects.



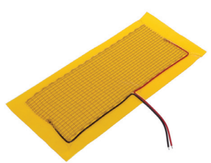
Temperature sensor probe is a contact-based transducer (thermistor, thermocouple, or RTD) that measures temperature and outputs an electrical signal for microcontrollers.



MPU-6050 is a MEMS 6-axis motion sensor combining a 3-axis accelerometer and 3-axis gyroscope, communicating via I2C for orientation and motion tracking.



HC-SR04 Ultrasonic Distance Sensor is a module that uses sonar pings via trigger and echo pins to measure proximity in microcontroller and robotics projects.



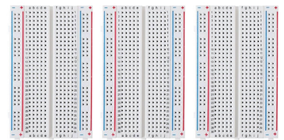
Electric Heating Pad is a flexible resistive heating fabric that warms up when powered (5–12 V)—ideal for wearable, DIY, and thermal-cycling projects.



9 g Servo is a tiny micro servo motor (~9 g) offering ~180° PWM-controlled rotation for precise positioning in microcontroller, RC, and robotics projects.



Servo is a compact rotary actuator combining a motor, gearbox, position sensor, and control circuitry to achieve precise angular positioning via PWM signals.



Breadboard is a solderless prototyping board with spring-loaded contacts for quickly assembling and testing electronic circuits without soldering.



Jumper cable is an insulated wire with connector pins at each end for solderless, temporary connections on breadboards and prototype circuits.



Battery pack is a collection of battery cells assembled with interconnects (and often management electronics) to supply portable DC power.



Arduino Software (IDE) is an open-source integrated development environment for writing, verifying, and uploading sketches to Arduino and compatible boards.



Processing is an open-source Java-based programming language and IDE designed for artists and designers to create interactive visuals, animations, and multimedia sketches.



Max 8 is version 8 of Cycling '74's visual programming environment for interactive audio, video, and multimedia prototyping via modular patching.



Shapr3D is a direct-modeling CAD app for iPad, Mac, and Windows, built on the Siemens Parasolid® engine for manufacture-ready 3D design.



My wife user testing Huggables

Project Overview

During one of our routine video calls in the spring of 2024, my spouse and I found ourselves longing for something that even the clearest screen and strongest signal couldn't deliver—a hug. We laughed about jumping out of our phones just to hold each other, but the ache behind the humor lingered. Though we could see and hear one another, the absence of physical closeness left a void that no call could quite fill. That moment became the emotional catalyst for what would later evolve into Huggables, and it raised a question that stayed with me: What truly makes us feel close?

That question moved with me into Design Seminar 2 at MassArt, where I began laying the groundwork for my thesis. Through primary field research—interviews, surveys, and conversations—I found that this emotional gap wasn't mine alone. Across stories from others in long-distance relationships, the most common thread was a yearning not for more words, but for more presence. People missed the comfort of physical touch, the warmth of another body, the subtle rhythms of breath and heartbeat—the quiet cues of intimacy that screens couldn't replicate.

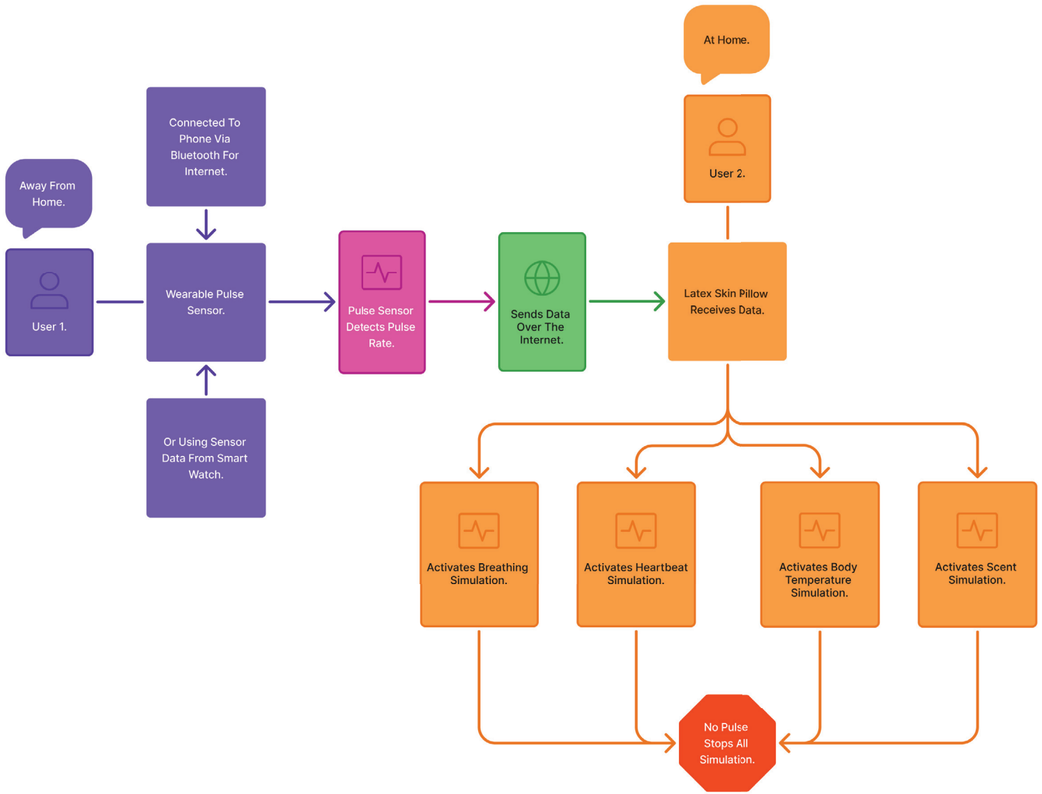
Out of this shared longing, Huggables took form. Developed in Design Studio 2, it is a set of two intelligent, connected body pillows designed to simulate the intimacy and comfort of a real hug. Each pillow is equipped with biosensors that collect real-time biometric data—heartbeat, breath rhythm, and body temperature—and transmits that data to its paired counterpart. The receiving pillow responds with synchronized tactile feedback: a gentle warmth that mirrors body heat, a slow rise and fall that mimic breathing, and soft pulses that replicate the sender's heartbeat. This tangible interaction is not intended to replace human touch, but rather to offer a comforting stand-in—a presence—when a loved one is physically far away.

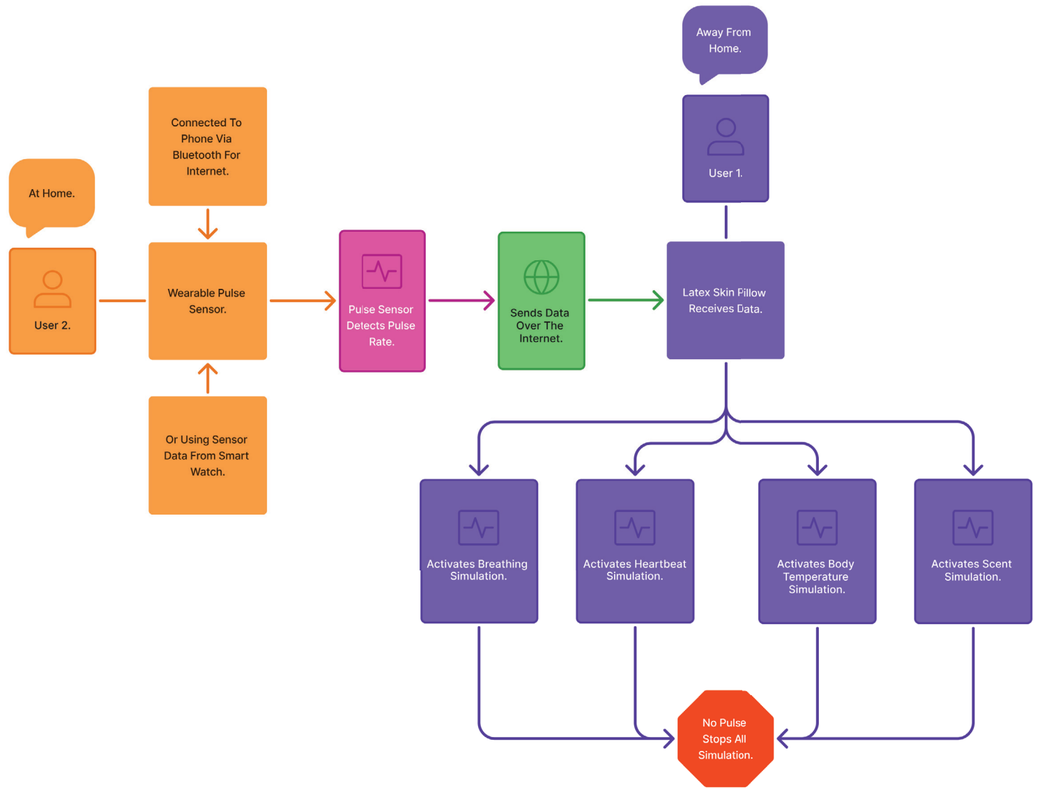
The concept behind Huggables is grounded in the understanding that physical touch is essential for emotional regulation, stress relief, and deepened bonds. In my own long-distance relationship, I found that verbal communication was constant, but something was still missing. With Huggables, my goal was to embrace the nonverbal nuances of connection—the ones that can't be spoken but are deeply felt. It is through these subtle cues—rhythms, warmth, pressure—that comfort and reassurance take shape, even in absence.

Huggables is grounded in personal experience—shaped by memory, longing, and the quiet moments of emotional absence that technology too often overlooks. While supported by academic inquiry, its soul is rooted in lived experience. It doesn't seek to replace human connection, but to hold a space for it—to make absence a little more bearable, and distance a little more tender.



User Journey Map





Concept & Development

That same call stayed with me—not just because of what was said, but because of what it led to. After the laughter, our conversation shifted. We began discussing what it would take to feel close—not just to communicate, but to sense each other's presence in a physical way. I mentioned how people already use body pillows and weighted blankets for comfort. She responded, "Yeah, but what if it could actually breathe—like gently moving as if someone's sleeping beside you?" I said, "Or feel warm—just enough to mimic body heat." Then she added, "And what if it could even carry a heartbeat? Something subtle, but real?"

That exchange became the starting point of Huggables. Each idea built on the last, and through that conversation, we shaped the emotional core of the project—thinking not just about functionality, but about how presence could be felt through small, layered signals. What began as a personal moment of distance became a shared design process—one where emotion and possibility worked side by side.



Body pillow Source: home of wool

At the same time, I was shaping my thesis direction in Design Seminar 2 at MassArt, guided by Professor Joe Quackenbush. That personal conversation naturally became part of my studio research. I turned to primary fieldwork—informal interviews and conversations with others navigating long-distance relationships. One common thread emerged: people didn't just miss talking. They missed being near someone. They missed the quiet reassurance that presence brings.

To test whether the idea resonated beyond my own experience, I also introduced the concept during my primary research. I posed the following question to participants:
"If there were a set of connected devices shaped like a body pillow for hugging that could simulate the physical presence of a person by mimicking their real-time heartbeat, breathing, and body temperature, how likely would you be to use it when they are absent?"
Responses were rated on a scale from 1 to 5, with 5 being very likely. The feedback was overwhelmingly positive—most participants responded with a 4 or 5, affirming the emotional relevance and usability of the concept. This helped reinforce the idea that Huggables could meet a genuine need shared by many.

These insights, both personal and collective, helped establish the foundation of the project. I focused on three sensory cues—warmth, breathing, and heartbeat. Each was chosen not only for its physiological grounding but for its emotional weight. These are the subtle signals that make us feel connected, even in stillness.

Huggables was designed as a pair of connected body pillows that collect and transmit real-time biometric data. One person's heart rate, breath rhythm, and body temperature are captured and expressed through tactile feedback in the paired pillow. The goal wasn't to replicate human touch—it was to offer a quiet sense of presence when being together isn't possible.

Contextual Research

Researching the Problem

As I began developing Huggables, it became clear that hugging carries both symbolic and physiological significance. It's a deeply human expression of safety, comfort, and intimacy. While Huggables doesn't aim to replace human contact, it exists in response to the absence of it—an absence that science tells us has a real, measurable impact. A growing body of research has shown that hugging has powerful effects on stress regulation, emotional wellbeing, and cardiovascular health. In one study, researchers found that people who engaged in regular warm partner contact—such as hugging and hand-holding—had significantly lower blood pressure and heart rate reactivity during stressful situations (Grewen et al.). It's not just the act of touch, but the consistency and warmth of it that seems to buffer the effects of psychological distress.

Jakubiak and Feeney build on this by exploring how affectionate touch fosters relational security. They emphasize that such touch communicates availability and responsiveness, noting that it plays "a critical role in cultivating intimacy and emotional well-being" (Jakubiak and Feeney 241). Huggables takes cues from this research—inviting users to engage with something that doesn't just imitate touch, but quietly affirms presence and connection in a time of absence.

But beyond hugging itself, the body's response to soft, slow, rhythmic touch has been studied in great detail. Neuroscientists McGlone, Wessberg, and Olausson describe how the skin contains specialized nerve fibers—C-tactile afferents—that are tuned to the kind of gentle touch associated with affection. These fibers, they argue, are integral to social bonding and emotional regulation (McGlone et al.). The deliberate, breath-like motion and warmth in Huggablesare designed to activate these fibers, offering a calming sensory experience that mirrors the soothing quality of human closeness. Touch is also a powerful communicator of emotion. According to Hertenstein et al., we're able to recognize a range of emotions—such as sympathy, love,

and gratitude—through touch alone, even in the absence of words or facial expression. Their findings suggest that "touch may be a much more nuanced and precise form of emotional expression than previously thought" (Hertenstein et al. 528). That insight shaped the nonverbal vocabulary of Huggables—a slow rising motion, a warm surface, a subtle pulsing—each cue designed to say something, without having to speak at all.

The absence of this kind of touch in long-distance relationships isn't just felt emotionally—it takes a physiological toll. Tiffany Field, a pioneer in touch research, has shown that tactile deprivation can lead to increased stress hormones, weakened immune function, and greater emotional instability (Field). Huggables offers a sensory bridge. This concept also finds support in developmental psychology. John Bowlby's foundational work in attachment theory asserts that emotional bonds and physical proximity are biologically programmed human needs. He writes, "the propensity to make strong emotional bonds to particular individuals is a basic component of human nature" (Bowlby 39). Ainsworth, expanding on Bowlby's work, revealed how consistent physical closeness—especially in early life—helps form a secure emotional base that individuals carry into adulthood (Ainsworth). In long-distance relationships, this proximity is often disrupted. Huggables was designed with this in mind: a gentle, responsive object to reinforce a sense of emotional availability, even from afar.

From a neurological perspective, research on mirror neurons offers another compelling lens. These neurons fire not only when we act, but when we observe someone else perform an action, allowing us to simulate others' experiences internally (Rizzolatti et al.). A pillow that mimics breathing or a heartbeat, then, may do more than comfort—it can evoke a felt sense of someone's presence. It invites the brain to complete the gesture emotionally, engaging memory and empathy through sensory cues.

Blakemore and colleagues add that imagined or observed touch—especially when emotionally meaningful—can activate the brain's somatosensory cortex in ways similar to actual physical contact (Blakemore et al. 1572). This means that even symbolic interaction, when paired with emotional context, can be genuinely felt. Huggables works within this space. All this ties back to the theory of embodied cognition—the idea that our thinking and feeling are deeply rooted in our bodily experiences. Margaret Wilson describes cognition as something that is "deeply rooted in the body's interactions with the world" (Wilson 625). Huggables aligns with this belief. It doesn't ask users to look at a screen or read a message—it invites them to feel through sensation, memory, and symbolic motion.

Existing Solutions

Earlier in this thesis, I've discussed a wide range of devices and design responses aimed at supporting emotional connection across physical distance.

From wristbands that vibrate when touched to speculative wearables that inflate on social media cues, the landscape is filled with attempts—some playful, some poetic—to make absence feel less empty. While these projects contribute important ideas to the conversation, only a few sit closely beside Huggables in terms of emotional intention, sensory depth, and physical form.

One such example is Pillow Talk by Little Riot. It allows long-distance partners to hear each other's heartbeat through a wristband and small pillow speaker. There's something undeniably tender about falling asleep to the sound of someone's pulse—it turns a biological signal into a shared moment. That gesture resonates with the goals of Huggables, but Pillow Talk primarily operates through sound. Huggables extends that intimacy through multiple senses: it doesn't just let you hear presence; it lets you feel it—through warmth, movement, and rhythm. Another reference point is The Hug Shirt by CuteCircuit. It was one of the early examples of wearable technology that tried to simulate human touch. By embedding actuators into fabric, it allowed users to send "hugs" to one another remotely. While it introduced an important concept, it leans more toward fashion technology and requires intentional interaction. Huggables takes a quieter approach. It's not something worn, activated, or sent—it's something held. It's meant for stillness, for sleep, for those slow moments when presence is most missed.

Projects like the Like-a-Hug vest from MIT Media Lab explored similar mechanics, using air inflation to simulate a hug when someone liked your social media post. It was clever, and it sparked conversation—but its interaction was more symbolic than relational. The breathing motion in Huggables was also inspired by inflation mechanisms, but here it's grounded in real-time biometric feedback. It's not about representing a "like"—it's about reflecting someone's actual breath, as if they're resting



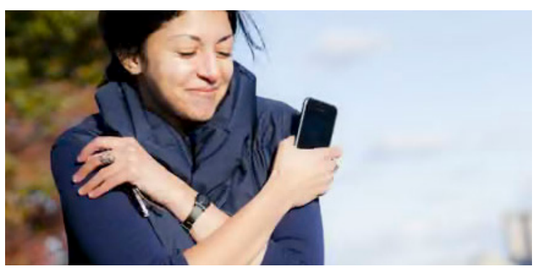
Pillow Talk by Little Riot



Hug Shirt by CuteCircuit

beside you. Other commercial devices like Kissenger and Fundawear explore remote intimacy through more literal or playful interpretations of physical contact. Kissenger, developed by Lovotics, allows users to send simulated kisses through a soft, silicone interface that replicates the pressure of a kiss in real-time.

It's a bold attempt to replicate a specific form of physical affection, but its emotional context is limited by the device's interaction style—it often feels more like sending a message than sharing a moment. Fundawear, a collaboration between Durex and Havas, takes a similarly experimental approach, using app-controlled vibrations embedded in underwear to simulate touch between partners. While these devices succeed in capturing attention and generating conversation around digital intimacy, they are often used sporadically, more as novelty experiences than daily rituals.



Like-A-Hug Jacket Source: The Guardian

By contrast, Huggables is designed for emotional longevity. It isn't about playful interaction or simulating an isolated gesture. Instead, it offers an ongoing sensory presence—soft, breathable, and warm—something that can quietly coexist in a bedroom, a moment of rest, or a long night spent apart. Where projects like Kissenger and Fundawear focus on replicating a single, momentary touch, Huggables is about creating a sense of presence that endures. What sets Huggables apart is how it doesn't ask for interaction. It doesn't require a button to be pressed, a message to be sent, or a notification to be received. It simply listens to one partner's biometric signals and responds in real time. There's no on/off switch for love, for missing someone, for needing to feel close. Huggables understands that. Its design speaks in slow, soft gestures—ones we recognize not through our eyes or ears, but through our body.

Design Process

From the outset, I approached Huggables using a modular design strategy. I broke the system into three core modules: sensing, actuation, and communication. This modular structure allowed me to build each system independently, troubleshoot in phases, and progressively integrate the components into a cohesive, responsive object.

Sensing Module

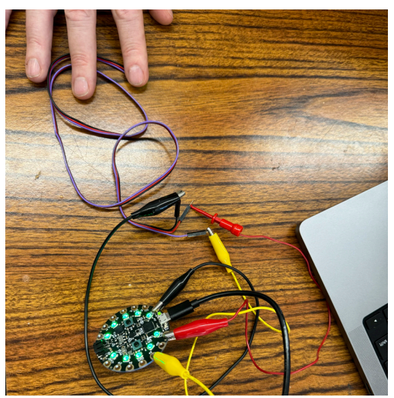
The sensing module was developed to capture three critical biometric metrics: heart rate, body temperature, and breathing. These signals were selected not only for their physiological value but for the emotional role they play in how we perceive someone's presence. To begin prototyping, I used the Circuit Playground Express, a microcontroller with a compact form and several built-in sensors.

It featured a temperature sensor and three-axis accelerometer, which proved essential to early development. I also connected an external Pulse Sensor to track heart rate. The onboard temperature sensor captured body warmth, while the accelerometer was creatively repurposed to detect subtle vertical motion from the chest—allowing me to estimate breathing without requiring additional hardware.

This phase of development was guided by work I did in the Sensor Technologies for Interactive Envi-



Kissenger Source: kissenger.com



Sensing module early prototype with circuit playground express



Presenting huggables sensing module at MIT media lab

ronments course with Professor Mark Feldmeier, and supported in practice by Professor Fred Wolflink, who helped refine the early hardware iteration and offered direction in setting up the first visualizations. Together, we developed a Processing sketch that mapped the biometric data visually: a vertical bar expanded and contracted with breath, a horizontal bar pulsed with heart rate, and temperature shifts were reflected through color changes.Alongside the on-screen sketch, I also used the Neopixels embedded on the Circuit Playground Express to visualize breathing directly on the hardware. During inhalation, the Neopixels glowed green; during exhalation, they turned red. This physical feedback helped confirm sensor performance and made the system feel immediately interactive, even in its early form.

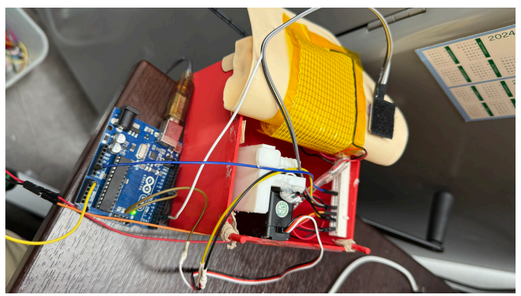
By the end of this phase, I had a compact, modular sensing system that could reliably collect real-time biometric data and express it in multiple forms. It established a technical foundation for building out the rest of Huggables.

Actuation Module

With the sensing module functioning, the next challenge was translating biometric data into tactile feedback. The actuation module is where Huggables becomes physical—simulating warmth, heartbeat, and breath to convey presencethrough sensation. In this system, sensors feed data to the microcontroller, which processes it and sends output signals to the corresponding actuators. The sensors themselves are not directly connected to the actuators; instead, the microcontroller serves as the decision-making unit at the center of the feedback loop.

To simulate body warmth, I tested several heating components and eventually selected a flexible heating pad from Adafruit. It maintained a safe, consistent temperature and was thin enough to integrate within the pillow. When one pillow registered a body temperature around 36°C, the other matched it—creating the feeling of someone physically near.

For heartbeat feedback, I used the real-time pulse data to drive a coin vibration motor controlled by a haptic motor driver. The motor pulsed gently in sync with the heartbeat signal, and I added slight natural irregularities to the rhythm to make the feedback feel more organic. This rhythmic vibration inside the pillow became a core emotional cue.



Huggables – Second Prototype
A pulse sensor reads the wearer's heartbeat and triggers a 3D-printed linear servo, a gentle heating pad, and a vibration motor.

Simulating breathing was the most technically demanding task. I was inspired by a childhood toy—a plush cat that appeared to breathe while sleeping. I ordered a modern version, reverse-engineered the internal structure, and discovered it used a linear actuator. I then designed a custom system using a servo motor, programmed to move in slow, rhythmic cycles. Enclosed in a 3D-printed protective shell, the mechanism gently expanded and contracted a padded surface to simulate the rise and fall of breath.

At this stage, the microcontroller—now upgraded to an Arduino Uno R4—handled all sensing and actuation. It received inputs from the sensors and used them to control the vibration motor, heating pad, and breathing mechanism in real time. This created a layered feedback loop that felt not just functional, but emotionally expressive.

The actuation module proved that physical feedback could be meaningful when done with care. Each motion, pulse, and shift in temperature worked together to create a believable sense of presence.

Communication Module

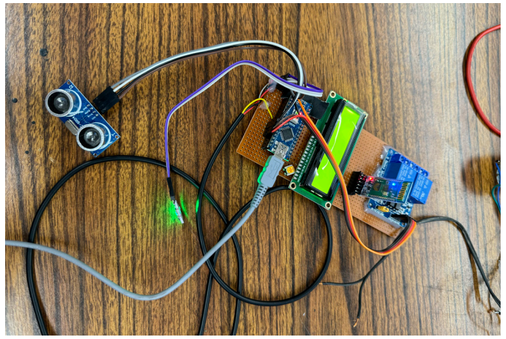
With the local system complete, I began working on the final piece: enabling wireless communication between two Huggables units. This was essential for transforming the device from a personal object into a shared experience.

Since the Arduino Uno R4 lacked networking capabilities, I transitioned to the ESP32-C6 microcontroller, which supports Wi-Fi, Bluetooth, and ESP-NOW—a lightweight peer-to-peer protocol suitable for low-latency data transmission between devices.

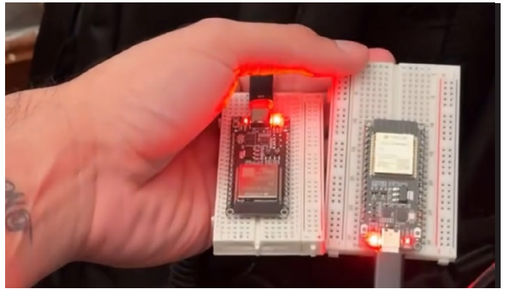
I began by testing simple data exchange: syncing an LED blink between two ESP32 boards. Once the connection proved stable, I migrated the full sensing and actuation code to the new platform. With this setup, biometric data—heartbeat, breath, and temperature—could now be sent from one pillow to another in real time, allowing each unit to respond to the other's physical signals.

While global remote connectivity would eventually require additional infrastructure (like cloud services or dedicated networking hardware), this local wireless setup was an essential first step. It validated the idea that presence could be transmitted not just simulated.

At this point, I turned my attention to the pillow's physical form. Early prototypes were enclosed in



During a rushed trip to Pakistan for a family health emergency, I commissioned an electronics shop there to build one of the first Huggables prototypes—but it never worked.



First successful experiment connecting two esp32-c6 boards to each other wirelessly using espnow, oboard LED blinking in sync.

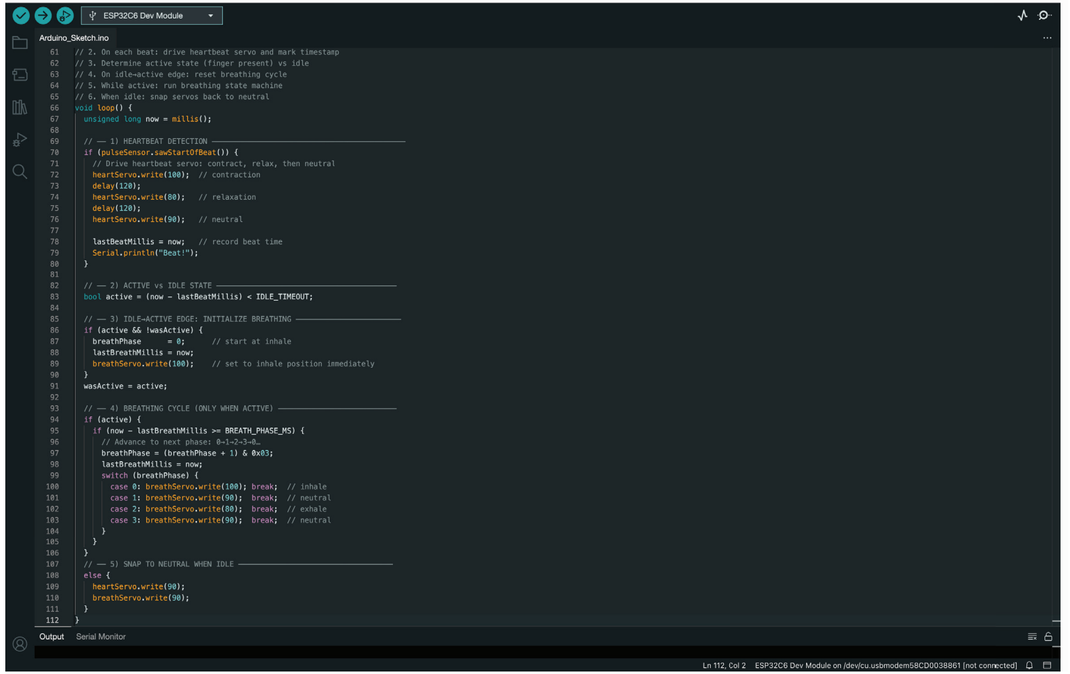


I conducted a sensing-band design workshop in which students sculpted their own ideal, comfort-focused band from clay.

Arduino Sketch

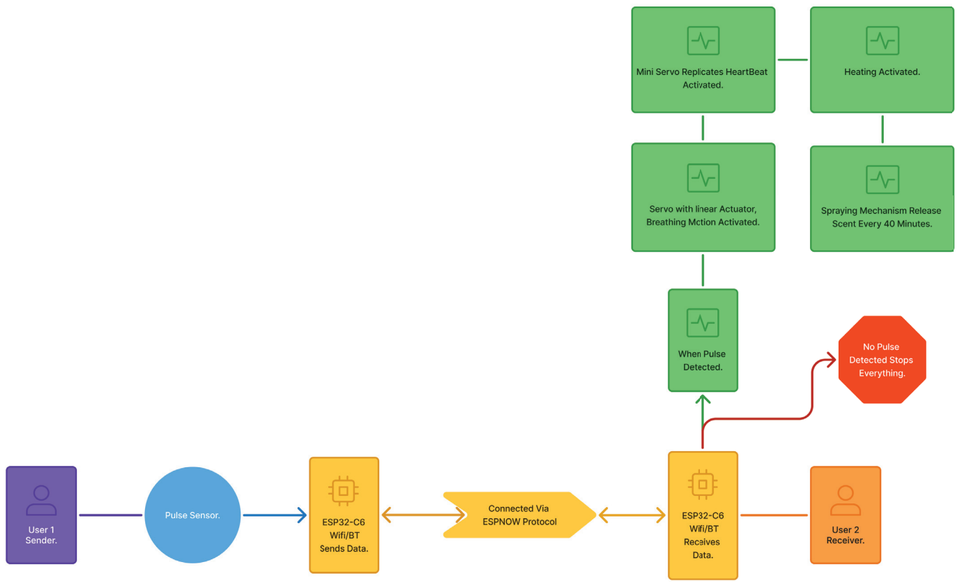


The sketch constantly samples the analog pulse sensor and applies a simple peak detection algorithm to find each heartbeat. Whenever a beat is detected, it commands a servo to perform a brief “throb” motion that matches the timing of the user’s pulse. At the same time, a linear actuator is driven through an inhale–exhale cycle—either at a fixed rhythm or loosely tied to the variability in the heartbeat—to emulate breathing. Meanwhile, a heating element is modulated via PWM in a basic feedback loop to hold



a target temperature around 37 °C, giving a skin warmth sensation. All of these tasks—pulse reading, servo movement, linear motion, and temperature control—are organized into separate routines within the main loop, so each physiological signal is recreated in real time without getting bogged down in complex interdependencies.

Hardware, Code Logic and Function



rigid plastic—effective for testing but lacking the comfort and emotional quality needed for a product meant to be held close. I began experimenting with outer materials: cotton, French terry, stretch knits, and fleece fabrics. While each option offered softness, none had the subtle realism I was looking for. Eventually, I discovered artificial tattoo practice skin—a latex-like material used for training by tattoo artists. It had a slightly elastic, skin-like texture that felt unexpectedly lifelike. When combined with fiberfill stuffing, it brought the pillow closer to what I had envisioned: a soft, responsive object that felt intimate to touch. By integrating wireless communication with a warm, skin-like form, Huggables became more than a technical project. It evolved into an emotionally resonant object—one that could carry presence across space, quietly and meaningfully.



Latex Tattoo Practice Skin Source: amazon.com

User Testing and Feedback

Once I had a functioning prototype, I was eager to learn how people would respond to Huggables in real-world scenarios. While the concept of simulating warmth, heartbeat, and gentle motion seemed conceptually straightforward, I understood that individual perceptions of tactile feedback could vary greatly. Collecting an array of perspectives was therefore crucial in refining both the technical features and the emotional resonance of the project.

My first significant round of user testing occurred during a summer visit home, where my wife took the role of the inaugural tester. She was moved—to see our "hugging pillow" notion turn into a workable prototype. Although she admired its core intention, she highlighted two immediate drawbacks: the mechanical feedback was too delicate, and the startup process felt cumbersome, requiring multiple sensors to be worn and synchronized. This feedback immediately pushed me to reconsider how many biosignals I truly needed to capture to preserve the project's sense of comfort.

Seeking further insights, I demonstrated the prototype to a broader group of family members and friends, amassing feedback from around 20 participants. Many described the overall idea as "deeply comforting," noting that the gentle warmth and subtle vibrations evoked memories of loved ones. Some shared that hugging the pillow felt "closer to

a real human embrace" than they would have imagined, describing the lifelike pulsing and warmth as unexpectedly authentic. A few individuals even became momentarily emotional, recalling the experience of genuinely missing someone they wished they could hug. Conversely, some pointed out that handling multiple sensors reduced the immediate sense of ease, making the technology feel more like a clinical setup than an intimate, human-oriented device. Motivated by these observations, I streamlined the design to emphasize the heart rate measurement. Since the heart pumps blood throughout the body, centering the entire actuation process around a pulse sensor felt symbolically appropriate—one vital signal powering the rest of the simulation. This shift both minimized the setup time and made the experience more approachable, allowing users to quickly immerse themselves in Huggables' core objective without juggling an array of biosensors.



A visitor at FreshMedia tests Huggables

When I debuted the refined prototype at the Annual Fresh Media Show in March 2025, attendees approached Huggables with curiosity and often left with surprisingly emotional reactions. By simply reading a project description, many immediately grasped the connection between heart rate and the pillow's gentle, rhythmic vibrations, and were delighted by how lifelike the experience felt. Several visitors explicitly commented on how hugging the pillow evoked an uncanny sense of "someone breathing and pulsing" in their arms, underscoring the power of tactile simulation to bridge emotional distance. One attendee enthused that "it felt like hugging a real person" after a moment of acclimation. My instructor, Abraham Evensen Tena, echoed these sentiments, praising the pillow's ability to connect with people on a personal level—tapping into longing and nostalgia.

Ultimately, this round of user testing reaffirmed the significance of balancing technical sophistication with emotional simplicity. While mechanical and electronic complexity lays the groundwork for realism, the true success of Huggables depends on its capacity to let users feel an emotional bond without the friction of complicated sensors. In every iteration, I grew more certain that even a pillow, enhanced by thoughtful design and inventive technology, can restore a sense of closeness for those separated by distance.

Conclusion

My Journey in the Making

While I write this case study, it's difficult to capture the countless hours poured into this project—the invisible weight of late nights, repeated failures, and hard-won breakthroughs that shaped Huggables into what it eventually became. On paper, it may read like a linear process, but it was far from easy. I had to teach myself how to code from scratch, a daunting endeavor for someone who wasn't particularly proficient in programming. The planning phase felt simple in comparison—everything was still theoretical, untested. But the real challenge began once I started building, turning abstract ideas into tangible form.

The prototyping phase alone went through multiple iterations, evolving from paper sketches to experimenting with various technical components. I had to navigate an entire landscape of learning—Processing and Arduino were foreign to me at the start, and while I received help from mentors and peers, the ultimate breakthroughs came only after relentless self-learning and problem-solving. Sensing was the first major hurdle to overcome. Once that was functional, actuation became the next beast. Replicating heartbeat patterns and warmth was relatively straightforward, but mimicking the gentle, rhythmic rise and fall of breathing was an entirely different challenge. Coding the algorithm for that motion and building a 3D-printed linear actuator that could simulate it realistically took several failed prototypes and countless tweaks. At one point, I was even dissecting toys to understand their mechanics and reimagining how those components could serve a new, emotional function in my work.

Another major hurdle was achieving wireless communication between microcontrollers—a critical component for making the experience feel authentic and unbounded by physical cables. This part of the project consumed a great deal of time in research and troubleshooting. To communicate the concept clearly, the sensing and actuation needed to be seamless and wireless, and that demanded both technical precision and emotional clarity in the experience design.

What I Learned

On a personal note, developing Huggables became a masterclass in learning through making. I started with only a passing familiarity with microcontrollers, yet soon was writing C++ to debounce sensors, parsing serial streams in Python, and troubleshooting I²C conflicts at two in the morning. Every technical obstacle pushed me into new territory: modeling a custom servo mount in Shapr3D, printing it at sub-millimeter tolerance, and integrating

flexible latex layers that could move without tearing. I scavenged heating elements from discarded hand warmers and refined the internal layout, so wiring remained unobtrusive. These improvisations proved that constraint breeds creativity—and that failure is simply data in disguise. With each iteration I inched closer to the emotional core of the design, refining how pressure, temperature, and rhythm could whisper "I'm here" without a single word.

Equally vital was learning to weave narrative into circuitry so engineering would serve emotion rather than overwhelm it. I began shaping sensory arcs: a soft heartbeat as greeting, a gradual bloom of warmth as the user settles in, and a slow, steady breathing motion that invites calm. The first time a neopixel shifted hue in sync with a pulse sensor, I felt a quiet thrill; the first time the pillow rose and fell in a rhythmic cadence, it felt less like a prototype and more like a companion. Huggables ultimately taught me to treat hardware as a language—one that speaks through subtle tactile cues—and to listen closely enough that every line of code, every layer of material, contributes to a conversation about presence, care, and human connection.

The Outcome

After completing the full cycle of designing, building, and user-testing Huggables, it became clear that the project achieved its primary goal: to demonstrate that tangible, sensory interactions can reduce the emotional distance felt in long-distance relationships, and that Huggables is a successful example of how this can be done. Through its layered system of warmth, vibration, and breathing simulation, Huggables offered something that screens and voices alone could not—a physical sense of presence. The feedback gathered through user testing, surveys, and public demonstrations affirmed this. Participants repeatedly described the experience as "comforting," "surprisingly real," and "emotionally grounding." Many noted that it filled a gap left by conventional digital tools, helping them feel emotionally closer to someone even in their absence.

However, the feedback wasn't uniformly positive, and that criticism offered important direction for improvement. Several users found the physical setup cumbersome—especially during early iterations when multiple sensors needed to be worn or aligned precisely. Others noted that the breathing simulation, while conceptually strong, occasionally felt mechanical or inconsistent depending on positioning. There were also concerns about setup time and the lack of a streamlined user interface. While the emotional impact was strong, the physical design still felt like a prototype to many, rather than a seamless, everyday object.

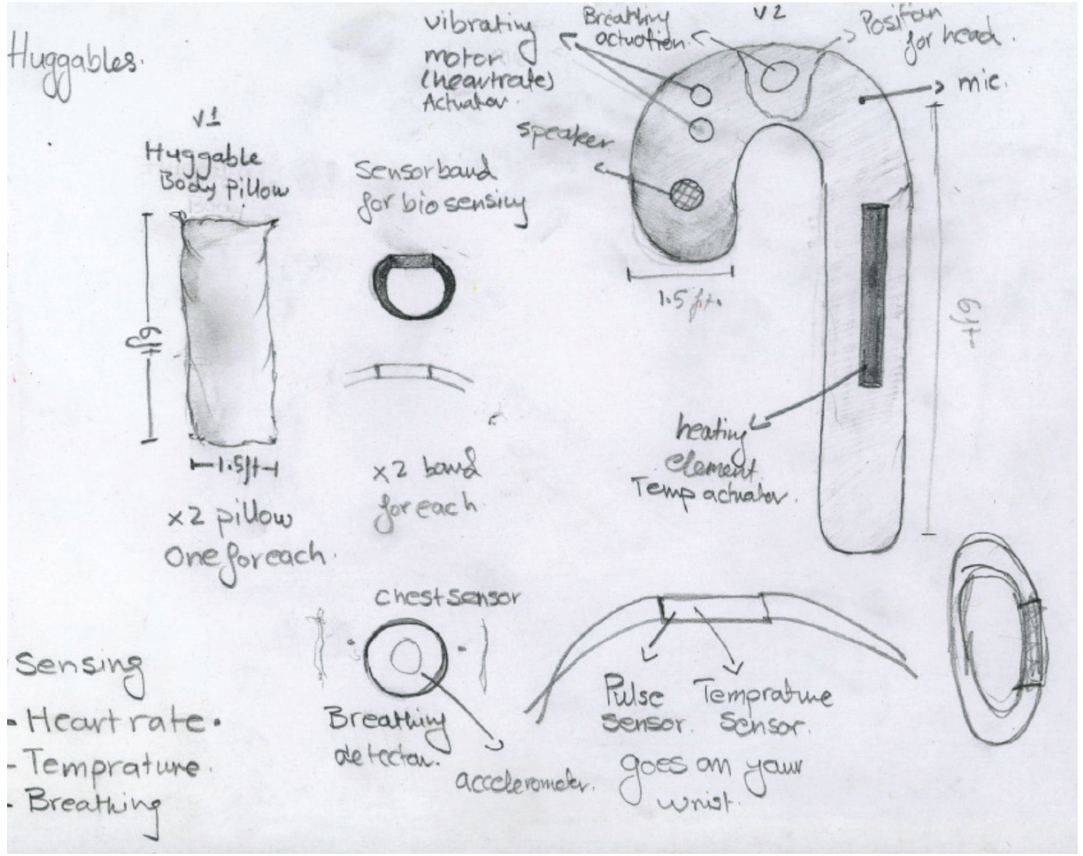
These critiques highlighted the gap between emotional resonance and technical polish. In terms of presence and connection, Huggables proved its point. But to move from prototype to product, it would need further refinement—particularly in terms of ergonomics, ease of use, and consistency across different user environments.

In summary, the project demonstrated that tangible feedback systems can meaningfully reduce the emotional strain of physical separation, and that Huggables—as a system and an idea—has the potential to evolve into a lasting tool for connection. It achieved its emotional and technical ambitions, while also revealing the work still required to make it more accessible, scalable, and comfortable in everyday use.

The Future

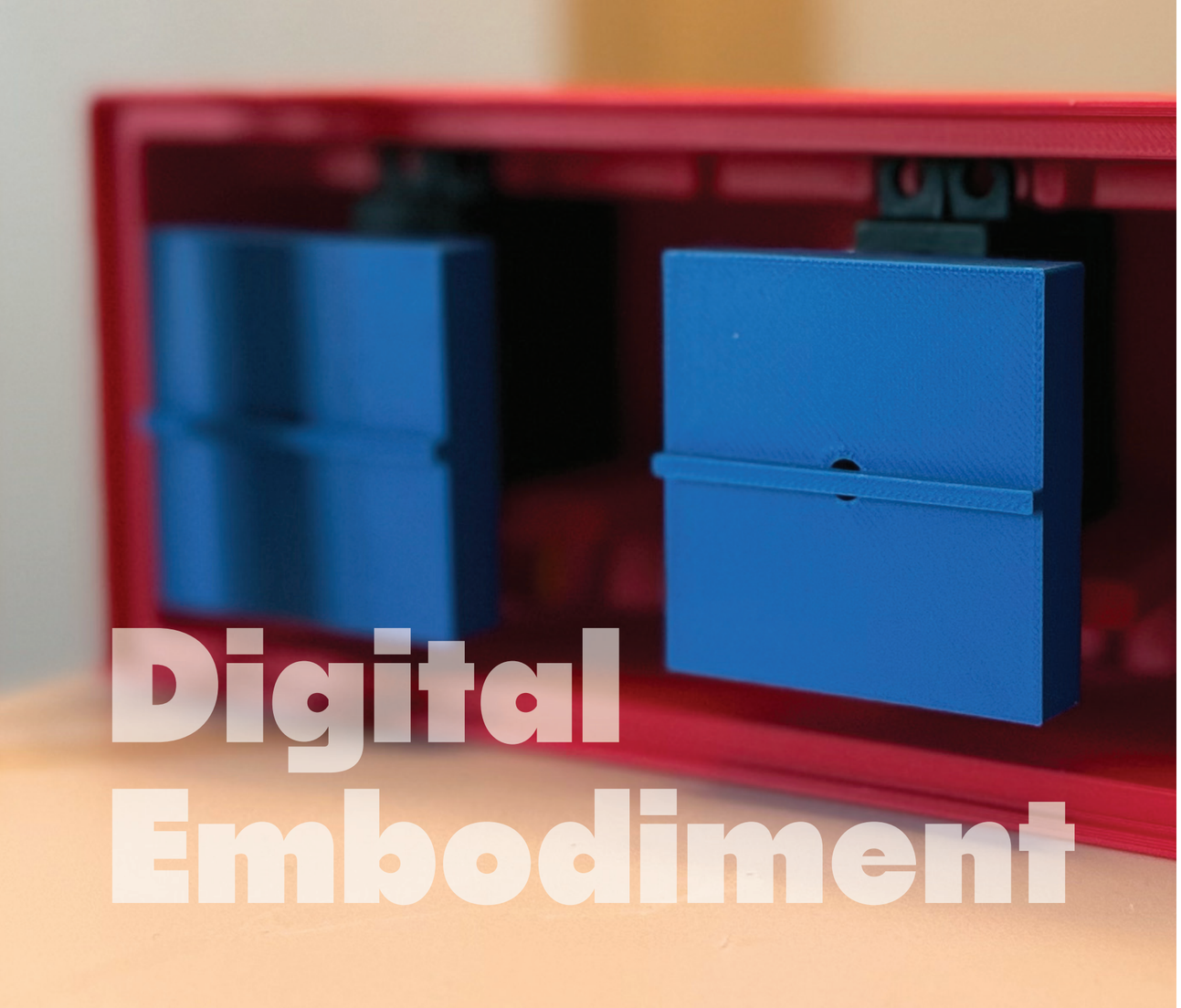
Looking ahead, Huggables can evolve well beyond its current prototype into a richly multi-sensory presence device. The first layer of refinement is secure, low-latency connectivity so two pillows exchange biometric data in real time; when one partner's heart rate speeds up or breathing slows, the corresponding pillow would echo that shift instantly, collapsing miles into tactile empathy. On top of this link, a sleep-tracking routine could adjust warmth and vibration automatically—subtle during deep-sleep phases, more responsive during light sleep—so the pillow behaves like an attentive bedtime companion. Because comfort thresholds differ, a discreet dial or capacitive slider tucked along the edge would let each user tune the feedback from a barely perceptible flutter to a steady, reassuring thrum. A low-latency two-way voice channel could turn the pillow itself into a soft, ambient speaker for whispered good-nights and impromptu conversations, while a replaceable scent cartridge would let users release a familiar fragrance on cue, engaging memory through smell.

To streamline sensing and improve data fidelity, the system could borrow from the Whoop fitness tracker's design language by moving core sensors into a slim wristband. This wearable would continuously capture heart-rate variability, skin temperature, and breath rate, then stream that information to the pillows over an energy-efficient link. Off-loading sensing to the wristband keeps the latex pillow pliable and unobstructed, while letting the device mirror a partner's authentic physiological rhythm—slowing to calm pulses as they nap, rising subtly as they wake. Combined, these enhancements would push Huggables toward its full promise: transforming warmth, motion, sound, and smell into a living conduit of presence for people experiencing long distance relationships.



Initial Sketches I made for huggables

Left Digital Embodiment And Right Huggables Showcased At Fresh Media



Digital Embodiment

Project Overview

The idea for Digital Embodiment, codenamed "Feelio," began taking shape during my Thesis Project One class in the third semester at MassArt. But its emotional foundation was laid much earlier—during quiet mornings in my apartment in Boston, when the absence of my family became something, I didn't just notice but felt. I missed their presence in the space—the scent of chai brewing in the kitchen as my mom moved through her morning ritual, the creak of a door opening, the subtle shift in the air when someone walked into a room. I missed the sound of my father watching the news at full volume, the quiet hum of my wife singing to herself, the familiar hallway chatter, my daughter's laughter echoing as she ran around the house. These ambient, sensory details always grounded me. Without them, the distance between us felt heavier. It wasn't just geographical—it became emotional.

That feeling wasn't mine alone. It revealed itself during video calls with my family, in the way they spoke about missing my presence. Not the conversations themselves, but the familiar sounds of my movement, the spontaneous energy I brought into shared spaces, the way the home felt different simply because I was in it. They said, "We can talk to you, but it's not the same. What we miss is you—being here." That moment stayed with me. It made me realize that presence isn't just about communication—it's about being felt in a space. That realization led me to ask: What if technology could recreate not just conversation, but presence? What if we could preserve and transmit the ambient cues that make someone feel close, even when they're far away?

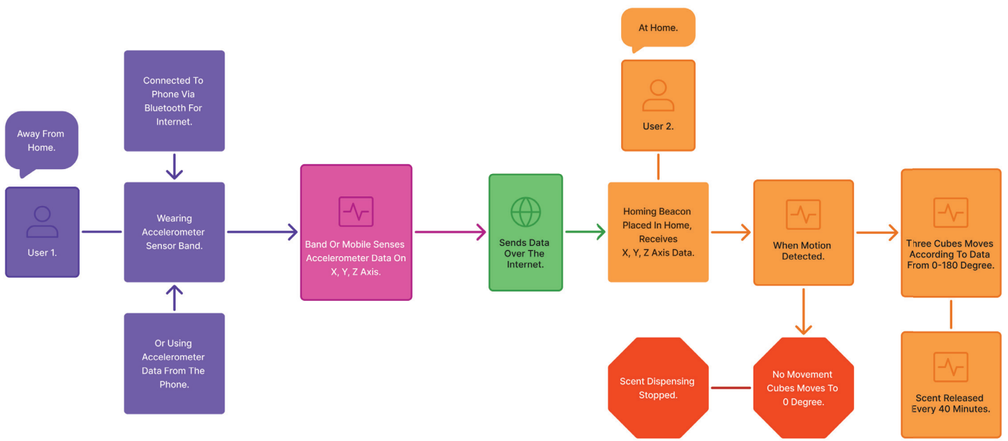
Digital Embodiment is my response to that longing. It's a kinetic sculpture created to evoke the presence of a loved one who is physically elsewhere, bringing a trace of their energy into the shared space they once occupied. The system consists of two parts: a wearable band, worn on the wrist by the person who is away, which tracks their motion and transmits it in real time, and a homing beacon placed in their home. The beacon is not just a receiver—it becomes a symbolic embodiment of the distant person.

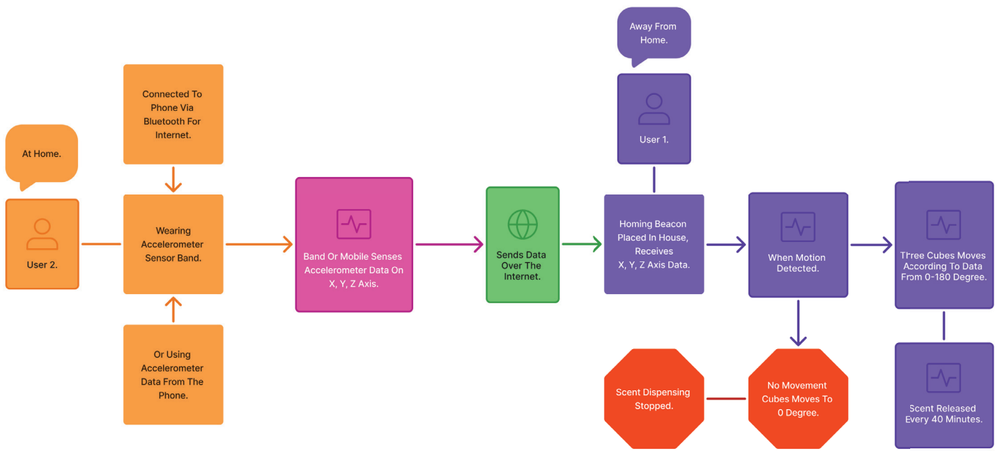
It transforms the wearer's motion data into a physical expression by controlling three interlocking cubes that move in response to their movement. To deepen the emotional resonance, the beacon also features a scent-spraying mechanism that intermittently releases a familiar fragrance—something personally associated with the wearer, like a signature perfume or a comforting scent. This multi-sensory response doesn't just signal presence—it allows presence to be felt. The goal isn't replication, but resonance—to translate presence into experience, capturing something subtle, that words and screens often miss.





User Journey Map





Concept and Development

As I began shaping Digital Embodiment, I realized I wasn't alone in how I felt. Through questionnaires and conversations with my wife, family members, relatives, friends, classmates, and other participants, I noticed remarkably consistent emotional patterns. People didn't just miss their loved ones—they missed their presence. That quiet sense of coexisting. The sound of movement in another room. The way someone's energy changes the feel of a space. It was comforting to understand that what I was experiencing was part of something deeply human and widely shared.

This became the emotional foundation I built the project on. I turned inward, revisiting the forms and materials that have long helped me process and express connection. Sculpture has been central to my practice since my undergraduate days at the National College of Arts in Lahore. Even then, I was drawn to the way sculptural work holds space—not just physically, but emotionally. There's something grounding about working with materials that respond to gravity, balance, and tension. Sculptures live in the same physical world we do. They carry weight—both literally and metaphorically.

Rather than designing for mimicry or replication, I began thinking symbolically. What might it look like to feel someone's presence without seeing them? Could a sculptural object respond quietly to a loved one's rhythm across distance? Could we reclaim the sensation of closeness not through screens, but through shared sensory cues?

This line of inquiry opened a more poetic, interpretive space to work in. I imagined objects that didn't move for attention, but in response to intimacy—gestures that quietly acknowledged a person's motion, their presence, their arrival. I envisioned these as emotional interactions rather than conventional technological features. The more I spoke with people—especially my wife and family back home—the more those instincts were confirmed.

From there, Digital Embodiment began to take shape as a sculptural response to absence. A way of translating motion, memory, and presence into a shared experience—one that could live in a room and remind someone that even when we're far, we're still reaching for each other.

Contextual Research

Researching the Problem

As I began speaking with people about the emotional weight of distance, one thing became clear: communication wasn't the problem in and of itself—presence was. Whether I was talking with my wife, my family, or others navigating long-distance relationships—relatives, close friends, classmates, and acquaintances—the sentiment was strikingly consistent. No one missed texting. No one missed the scheduled calls. What they longed for were subtle, atmospheric cues—sensory moments that made someone feel real in a space. The ambient rhythm of living alongside someone.

To better understand this emotional gap, I asked participants two related questions in my primary research questionnaire. The first was a scaled response: "In your opinion, how important is physical presence in emotional communication?" (with 1 being not important and 5 being very important). The overwhelming majority rated it a 5. That was followed by an open-ended prompt: "Can you explain why you feel this way?" One participant shared, "When you're physically around someone, even silence feels full. I don't need them to say anything—I just need to feel them nearby. No call or screen gives me that."

This quiet, wordless form of connection echoed something I was already experiencing in my own life: that presence is not just something you see or hear—it's something you feel in the space around you. As I dug deeper, I found that these feelings weren't just emotional—they were biological. Scientific research shows that memory and emotion are deeply entangled with our senses. The olfactory system, for example, is wired directly to the limbic brain—home to memory and emotional processing. That's why even a faint scent can collapse time and space, bringing someone back into the room with startling clarity (Herz and Schooler 218). Similarly, studies on affective touch show that a soft, familiar contact—like a hand on your arm—can do more to ease anxiety than a long conversation (Gallace and Spence 246; Field 372).

Even sound—especially non-verbal sound—has emotional weight. The cadence of a voice, the slight echo in a room, the ambient tones of being together. Music psychology studies show that tonal and rhythmic stimuli can stimulate areas in the brain responsible for empathy and memory (Juslin and Västfjäll 560), and in some cases, generate physical responses like goosebumps or tears (Sloboda 121).

These findings are reinforced by emerging work in affective computing and embodied interaction. Rosalind Picard's foundational research on emotional technologies stresses the need for systems that don't just send and receive information, but recognize and reflect human emotion in nuanced, responsive ways (Picard 1). Building on that, researcher Kristina Höök introduces the concept of somaesthetic design—a practice that encourages designers to consider how technology is experienced through the body, not just operated with it.

Somaesthetic interaction isn't about efficiency or functionality—it's about awareness. Höök's approach emphasizes movement, posture, breath, and the emotional resonance of bodily experience. The idea is that technology can engage us not just intellectually or visually, but through how it makes

us feel in our bodies. A slight shift in balance. A gentle rhythm. A sensation that stays with you long after the interface disappears (Höök 79). This philosophy aligns deeply with what I've been pursuing in Digital Embodiment—a way to reintroduce presence not through screens or avatars, but through atmosphere, motion, and sensory traces that live within the body.

These perspectives validate what I've come to believe through both data and lived experience: emotional connection is not purely cognitive—it's embodied. And for long-distance relationships, that's where the real absence is felt. What emerged from this research was a clearer articulation of the problem: sensory deprivation isn't just a side-effect of being far from someone—it's the central loss. And to truly design for connection, we must go beyond the screen. We need to create systems that respond to our bodies, that resonate through our senses, and that restore the intimacy of just being there—without needing to say a word.

Existing Solutions

In the contextual research section of this thesis, I explored a wide range of projects, technologies, and artistic interventions that attempt to bridge emotional and sensory gaps in long-distance relationships. From haptic wearables and scent-based communication devices to telepresence robots and immersive VR systems, many of these innovations share a common goal: to simulate presence in the absence of proximity. Yet even as these tools multiply and evolve, many of them still treat presence as something to be transmitted, not embodied. What remains underexplored is the ambient, symbolic, and sculptural nature of emotional presence—the slow, quiet language of simply being felt.

Beyond the mainstream examples already discussed, there are lesser-known works and emerging experiments that offer new insight. The "Eunoia II" project by media artist Lisa Park, for instance, transforms EEG brainwave data into water vibrations. Her shifting emotional states, measured in real time using a brainwave headset, ripple through shallow pools of water, giving emotional turbulence a material, meditative form. While not originally conceived as a tool for intimacy, the piece is a striking example of emotional presence being made spatial and sensory. It hints at a future where internal, felt experiences might be shared not through words, but through movement, rhythm, and texture.



Eunoia by Lisa Park Source: clotmag.com

Another artistic direction is seen in Studio XO's exploration of wearable technologies—fashion pieces that change color or behavior in response to biometric data, proximity, or touch. Though typically framed within performance and entertainment contexts, these reactive garments challenge the divide between the body and communication, opening questions about how clothing itself might become a medium for intimacy. They suggest that connection can be expressed through material shifts, through subtle pulses and changes in texture that mirror the emotional dynamics of a relationship. From a more conceptual angle, Ken Goldberg and Joseph Santarromana's Telegarden (1995–2004) offered an early look at mediated care and co-presence. Participants from around the world could log in, operate a robotic arm, and collaboratively tend to a physical garden in California. The system was slow and sometimes clunky, but what emerged was a kind of shared ritual—a symbolic experience of presence built not through speech, but through tending, timing, and attention. In the context of long-distance relationships, it asks: what if presence wasn't just about communication, but about collaborative rhythm? Each of these works expands the vocabulary of mediated intimacy in ways that feel resonant with the goals of this thesis.



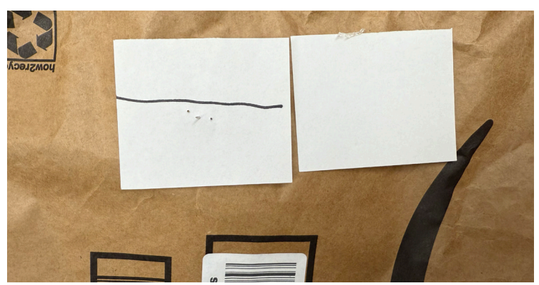
Studio XO Dynamic Dress Source: the guardian

They don't rely on hyper realistic simulation. They don't demand constant interaction. Instead, they gesture toward something quieter and more sustainable: the possibility of presence through ambience, symbolism, and slow design. This is the terrain where Digital Embodiment begins. Not as a device meant to simulate human presence with clinical precision, but as a sculptural system that reinterprets presence through motion, atmosphere, and emotional rhythm. It builds on existing ideas but intentionally veers into a space of symbolic metaphor—inviting not only interaction, but reflection. By drawing from the language of art, ritual, and emotional memory, this work contributes a softer, slower, and more human-centered approach to bridging distance.

Design Process

The development of Digital Embodiment began with sketches—simple visual explorations meant to untangle emotional questions through form. I wasn't just drawing mechanisms; I was thinking

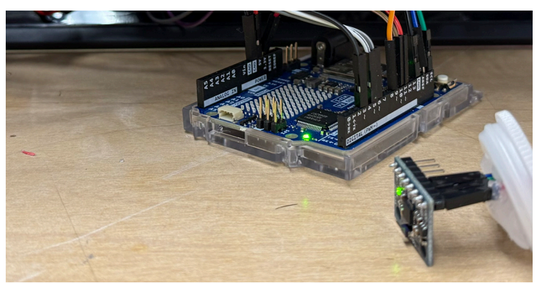
about absence, presence, and the space in between. What does it mean to be felt but not seen? What shape holds care, memory, or presence? These sketches became the first step in shaping a system that would translate quiet motion into an expression of connection. From there, I built a quick paper prototype—a single square cut from scrap paper, taped to an old Amazon envelope. I used a thumb tack from below to give it movement. It was crude, but it offered my first look at proportion, spacing, and material gesture. That early choice stayed with me and ultimately evolved into the system's final form. To structure development, I divided the project into three interconnected modules: Sensing, Actuating, and Communication. Each module addressed a specific layer of the experience—capturing human motion, translating it into physical response, and enabling its transmission across space.



First Paper Prototype made out of paper and thumb tack

Sensing

The sensing module was developed to detect nuanced, real-time human motion. I began by assembling the MPU6050 accelerometer and gyroscope with an Arduino UNO R4, using jumper wires to establish the circuit. To get it running, I explored example sketches within the Arduino IDE, which I used as a base to write a script that printed live motion data from the X, Y, and Z axes to the serial monitor. This initial test allowed me to verify that the sensor was responsive and stable, capturing continuous movement data in real time. Once confirmed, the sensor was integrated into a wearable band later on. Its role was to continuously capture ambient physical activity—subtle motion signals that could quietly represent a person's presence, without requiring explicit input or engagement.

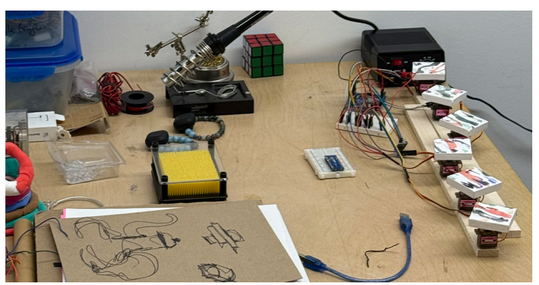


MPU6050 sensor connected to UNO R4 to get readings

Actuating

The actuating module is responsible for translating motion data into physical and sensory output. Once I confirmed that the MPU6050 sensor was reliably capturing movement data and displaying it within the Arduino serial monitor, I began exploring how that data could be used to drive physical response. To do this, I selected servos—compact motors capable of precise rotation.

The first physical prototype consisted of six 9g mini servos, each with a mini canvas attached to its shaft, mounted onto a piece of wood. These small canvases allowed me to visually track how servo movement could reflect gestures in space. This early test confirmed that servo motion could be successfully mapped to live sensor input. Following that, I streamlined the system. Instead of six mini servos, I shifted to three standard-sized servos,



First Actuating Prototype using mini servos

each directly mapped to one of the accelerometer's X, Y, or Z axes. These servos now rotated three custom-designed cubes, allowing for smoother motion and a clearer sculptural response. An additional fourth servo was programmed to press and release the nozzle of a spray bottle every 30 minutes—but only when motion was detected. This created a multi-sensory interaction where scent—often linked to memory—became a subtle marker of presence.

Communication

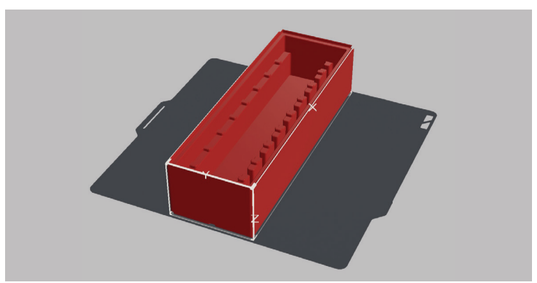
The communication module was responsible for transmitting sensor data from the wearable device to the homing beacon. In the initial prototypes, the components were wired together—connecting the sensor and servos to the Arduino Uno r4 microcontroller—which restricted flexibility and usability. As the project progressed, I transitioned to a wireless system using two ESP32 C6 microcontrollers connected via ESP-NOW, a fast, device-to-device protocol ideal for local communication.

One ESP32 read data from the wearable and transmitted it wirelessly; the second received this data and activated the servos and scent module accordingly. While the project was originally envisioned to work remotely over the internet, I found this method introduced lag and reliability issues, which made real-time user testing difficult. As a result, the final prototype remains wireless but operates within

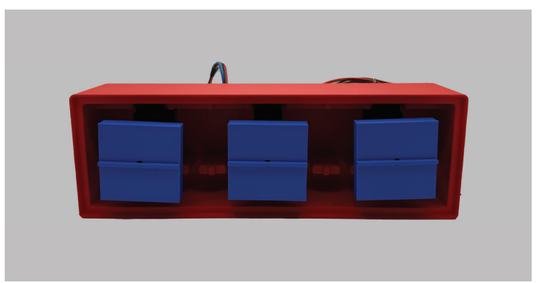
the same physical space. This choice allowed for a smoother, more stable experience—still meaningful, still ambient, and still rooted in the quiet signals of presence.

Once the technical modules were complete, I shifted my focus to form, symbolism, and materials. The beacon was modeled in Shapr3D, starting from an open-source base design, which I modified to meet the structural and aesthetic needs of the system. It resembles a minimal cuboid housing with three independently moving cubes mounted on the front. These cubes were designed from scratch and serve as the primary interface for expressing presence. Each cube features a single horizontal line across its face, inspired by a flatline on a heart monitor. When no motion is detected, the cubes align perfectly, forming one continuous, silent line. When the wearer moves, the cubes break formation, shifting to reflect presence through motion. The choice of the cube was deliberate—it offers a neutral but grounded geometry. As Wong (1993) notes, cubes and square-based forms often symbolize balance, dependability, and stability—qualities that speak to the emotional reassurance we seek in long-distance relationships.

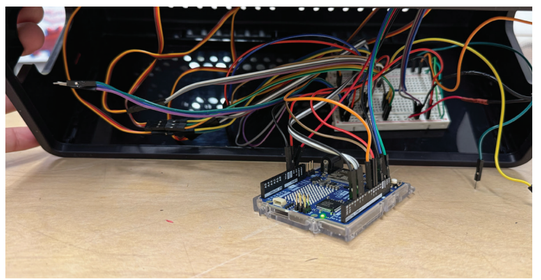
Color was chosen to heighten these emotional contrasts. The homing beacon was printed in red, a color tied to urgency and emotional alertness. The cubes were printed in blue, symbolically connected to water—reflecting fluidity, adaptability, emotional depth, and life's essence, echoing the significant water content in the human body. As color theory research notes, red tends to stimulate attention and action, while blue evokes trust and introspection—together forming a visual language that communicates presence both viscerally and emotionally (Elliot & Maier 2014). Finally, practicality and comfort were prioritized as I transformed the accelerometer sensor into a discreet and comfortable wearable band, facilitating effortless everyday use. This transformation completed the project's symbolic, functional, and emotional coherence, resulting in Digital Embodiment becoming an intimate and meaningful experience for users.



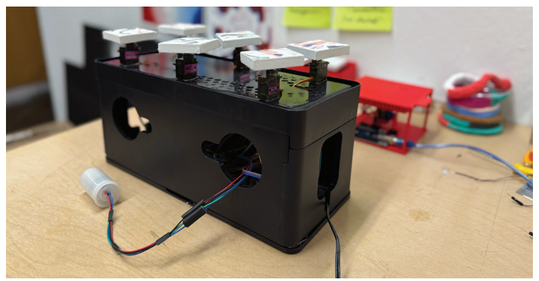
Initial beacon design, opensource CAD by @cadandcookies



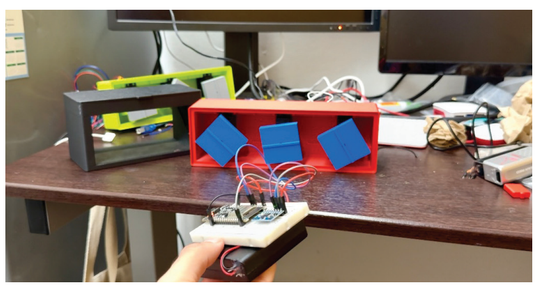
Final form Digital Embodiment



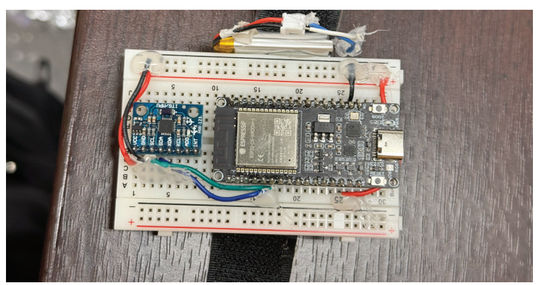
Internal view of the second prototype's wiring and circuitry



Second Prototype with wired sensor and six mini servos as actuators



Third Prototype with wireless sensor and three servos as actuators, with a more polished form



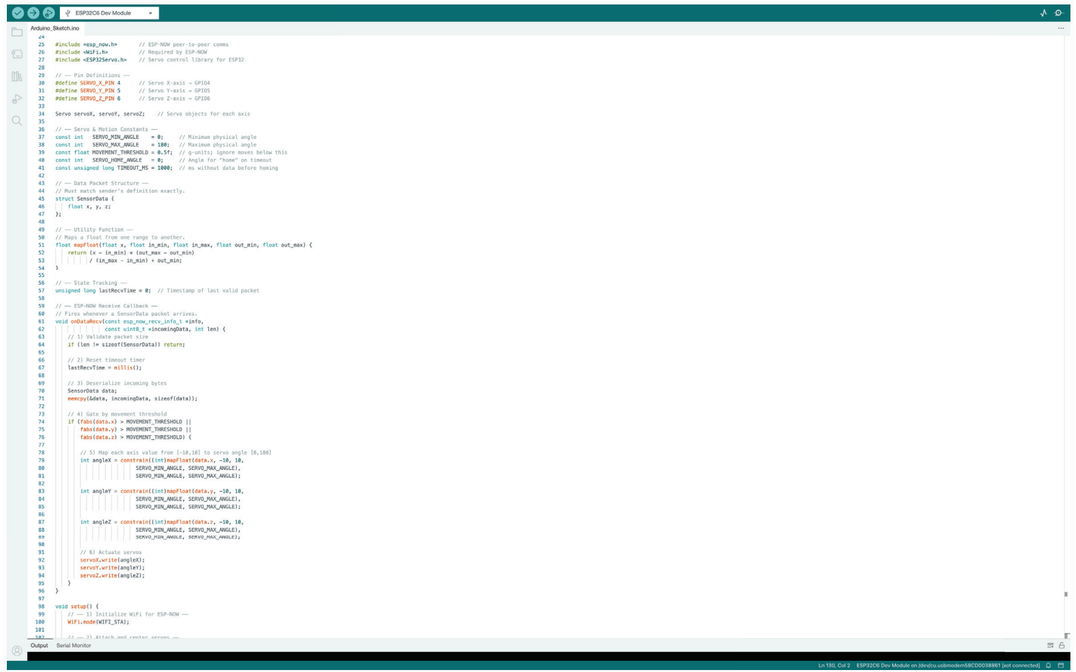
Closeup shot of the wireless sensing band. A MPU6050 plugged into ESP32-C6 Board

Arduino Sketch

Sender

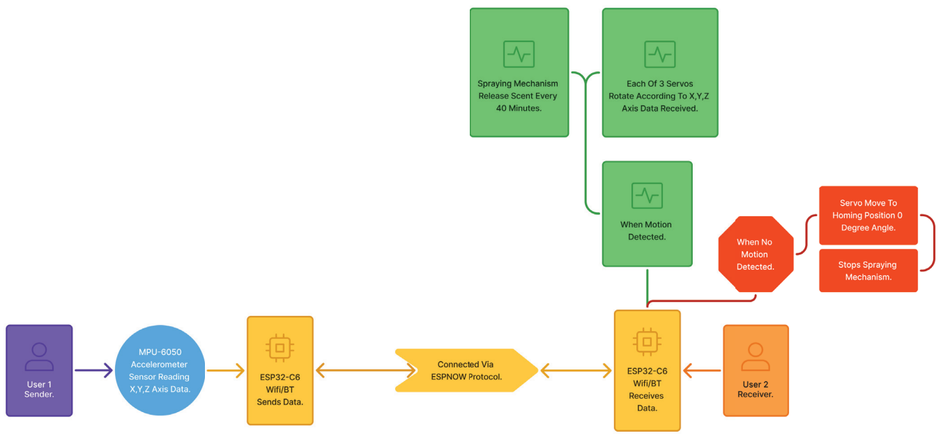


Receiver



In these sketches, the functionality is split into two distinct programs: one running on the sender ESP32 and one on the actuator ESP32. The sender sketch continuously reads X, Y, and Z acceleration data from an MPU6050 and transmits it over ESP-NOW in compact packets. Meanwhile, the actuator sketch listens for those packets, converts each axis value into a matching servo angle, and drives the motors so the physical setup mirrors the sensor's movements in real time. If the sender goes offline or the incoming motion values fall below a set threshold, the actuator automatically triggers a homing routine that returns every servo to its zero position, providing a reliable "reset" whenever communication is lost or motion stops.

Hardware, Code Logic and Function



User Testing and feedback

Digital Embodiment underwent extensive user testing and iterative refinement, offering invaluable insights at each stage. The very first tester was once again, my wife, who immediately resonated with the project's core concept, agreeing that the movements successfully symbolized physical presence. However, she pointed out that the mechanical noise produced by the servo motors was somewhat distracting, taking away from the immersive and emotional experience I aimed to deliver.

The project was subsequently featured twice at DMI's annual Fresh Media exhibition. In its initial showcase, Digital Embodiment appeared as a raw prototype with visible wires connecting the sensor, and servos randomly moving miniature canvases. Observers initially expressed confusion due to the project's rudimentary aesthetics and exposed wiring, often unsure of what exactly the installation represented. Reading the provided project description helped clarify the concept for some; however, feedback highlighted the need for more visually cohesive and symbolic representation. Comments included, "Interesting idea, but what exactly am I supposed to see?" and "The movements seem intriguing, but the setup feels incomplete." Such early responses helped me realize the importance of clearly communicating the project's emotional intention visually and functionally.



Fred interacting with an earlier prototype at Freshmedia

By the second Fresh Media exhibition, Digital Embodiment had significantly evolved, now featuring fully wireless functionality and carefully designed aesthetics, including purposefully spaced cubes and a distinctively colored homing beacon. This refined iteration generated much stronger reactions, with visitors noticeably intrigued, amazed, and actively engaging with the piece. Many expressed excitement upon realizing that their movements wirelessly influenced the cubes. Comments such as "Wow, it feels like a futuristic toy," and "I can see how this represents someone's presence—it's fascinating!" indicated a strong appreciation for the symbolic interactivity and playful aspect. Others, captivated by the concept, spent time discussing its potential applications in personal relationships and emotional well-being, suggesting it could effectively convey presence in long-distance situations.

Still, the improved version wasn't without critiques. Some visitors remained uncertain about the realism of the experience, stating, "The idea is appealing, but I'm not fully convinced that movement alone can simulate real human presence." Another visitor remarked, "I understand the symbolism, but I wish there were more sensory elements." Such feedback was valuable, underscoring the complexity of simulating human presence and the varied emotional expectations users bring to such experiences.Overall, the user testing affirmed project's emotional depth, and symbolic power, while also highlighting areas for improvement—like sound management and richer sensory integration.



A Fresh Media visitor interacting with Digital Embodiment

Conclusion

My Journey in the Making

The journey wasn't easy. It was full of failed attempts, burnt chips, mismatched wiring, and moments of real frustration. I even got a deep cut on my palm while working on one of the early prototypes—a reminder that making can be as physical as it is mental. While I came into this project with some coding experience—thanks to my work on Huggables—I still considered myself an amateur. That said, I felt more prepared this time, and it gave me the confidence to dive into more complex systems from the beginning.

The early stages of prototyping were far from polished. I started with rough paper models to explore form and function. I vividly remember one of my first experiments: disassembling an old remote-controlled car just to understand how motion could be triggered remotely. It wasn't elegant, but it sparked the right questions. From there, I moved on to mini servos, tangled wiring, and a setup that looked like it had been assembled in a rush—because it had. But with every version, no matter how chaotic, I learned something essential. The failures were frustrating, but they were also foundational.

Gradually, I shifted from makeshift experiments to building a cleaner, more stable system—with a custom-designed enclosure, upgraded servos, and more refined logic. Each iteration deepened my understanding—not just of circuit design or code, but of how motion could carry emotional weight. It was in those late-night hours, soldering wires and debugging code under a desk lamp, that the project truly began to come to life.

This process wasn't just about building a prototype—it was about building resilience. About holding onto an idea that mattered deeply to me and pushing it forward, piece by piece, even when it felt out of reach. Every phase of prototyping added both technical knowledge and emotional resonance to the final piece, making the journey not just creatively rewarding, but personally transformative.

What I Learned

Working on Digital Embodiment—like many of my previous projects—was a deeply immersive learning experience. With each phase, I became more confident in working with microcontrollers, low-voltage electronics, and writing cleaner, more purposeful code. I learned how to troubleshoot hardware more efficiently, how to manage sensor data with better precision, and how to structure my code to support responsive, real-time behavior. I also advanced my 3D modeling and fabrication workflow, learning how to balance tolerances, fit, and movement across printed parts—especially in relation to servo interaction and enclosure design. This project also sharpened my understanding of how material, motion, and sensory detail could operate together as a form of nonverbal storytelling. I began thinking more critically about what gestures communicate in space, how rhythm and motion pacing affect emotional perception, and how scent, color, and texture could heighten the experience of presence in subtle but powerful ways. These weren't decorative decisions—they were conceptual ones, informed by emotional logic and driven by intent.

On a broader level, I also learned how to manage the arc of an idea—from rough sketch to working prototype—while staying responsive to feedback and friction along the way. Each phase required re-evaluating what the work needed to communicate and how clearly it was doing so. The process became less about refining an object and more about refining the conditions for meaning to emerge through it. This project marked a pivotal moment in my thesis journey. It helped clarify the kind of designer I'm becoming—someone who values technical literacy, but who leads with emotional sensitivity. Someone who believes that presence, memory, and care can be shaped not just by message or interface, but through how we move, build, and sense the world around us.

The Outcome

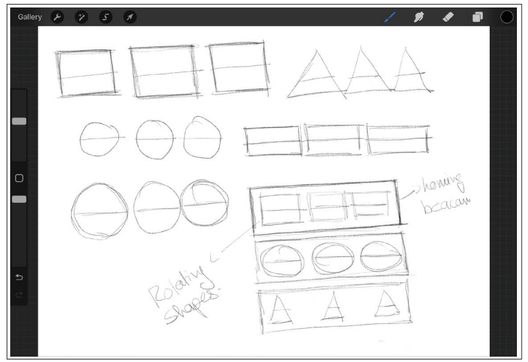
Overall, I was deeply satisfied with how Digital Embodiment came together. The final prototype aligned closely with the intent of my thesis: to bridge emotional gaps caused by physical distance through sensory-driven, symbolic communication. User testing affirmed that intention. Participants understood and appreciated that the piece wasn't just a device—it was a representation. A symbolic stand-in for someone far away, made tangible through movement, rhythm, and scent.

The project succeeded in activating key sensory cues—visual motion, olfactory memory, and ambient feedback—that reawakened emotional associations and made presence feel more immediate. One of the most meaningful insights came from observing how people instinctively began to associate the object with a human presence—especially once they understood it was reacting to real-time motion and carried a familiar fragrance. That realization shifted the interaction. It stopped being about the object and became about the person it represented. In those moments, presence was no longer just sensed—it was felt.

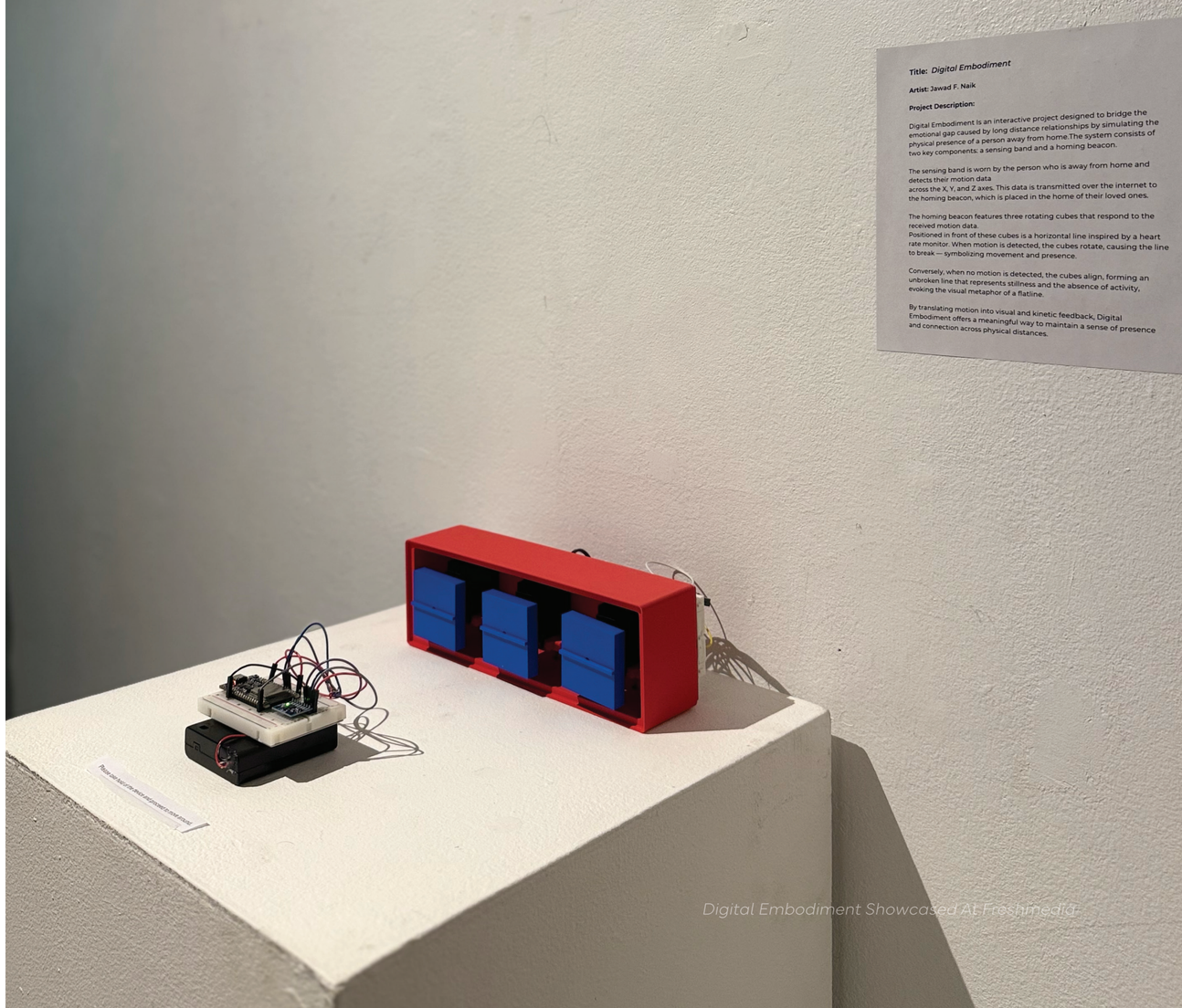
The Future

Looking forward, I see many directions to evolve this project. One immediate improvement would be to make the sensing module more seamless—perhaps by using an existing wearable device like a smartphone or smart Watch to serve as the motion sensor, reducing the need for a dedicated external component. I'd also consider scaling the experience—either by enlarging the current homing beacon to make a stronger visual and spatial impact, or by creating multiple smaller beacons placed throughout the home to create an ambient, distributed sense of presence.

To address the distracting sound produced by servo motors, I'm exploring alternative actuation methods, such as using magnetic mechanisms for silent movement. Another idea is to replace mechanical noise with subtle soundscapes or tracks that play in sync with motion detection—turning the sound into a more emotionally resonant part of the experience. Long-term, I envision an ecosystem around this idea—where users can personalize the shape, color, movement style. This would allow people to create versions that feel more intimate, culturally relevant, or aesthetically aligned with their environments, making the experience even more meaningful. Digital Embodiment isn't just a prototype—it's a framework for how we might reimagine presence, memory, and intimacy in a time when physical distance is more common than ever.



Some preliminary sketches for digital embodiment



Digital Embodiment Showcased At Freshmedia



Pulse Paint

Project Overview

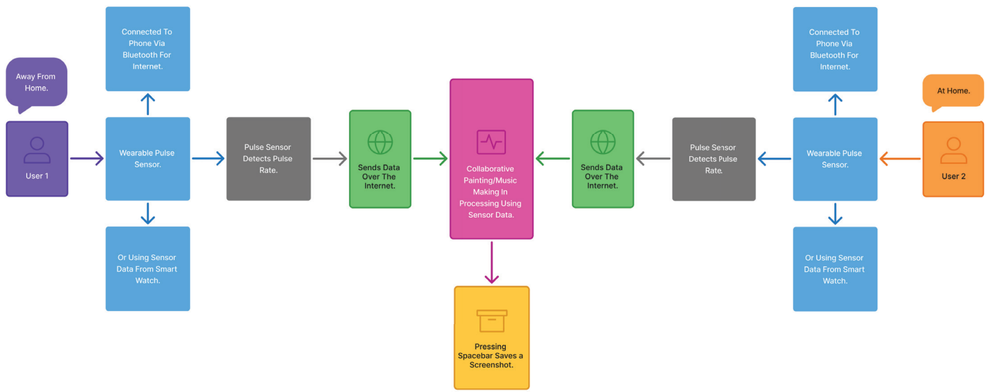
The initial spark for Pulse Paint came from a simple yet powerful question: What if love could be turned into a brushstroke? At the time, I was immersed in exploring how non-verbal cues—like rhythm, heartbeat, and touch—might become a new language of presence and intimacy. I was also navigating the personal reality of being far from my loved ones, especially my partner. Despite the accessibility of video calls and messages, there remained a silence between the words—a longing for the tactile, the spontaneous, and the shared.

Pulse Paint was developed during my third semester at MassArt as part of my Thesis Studio 1 course. It is a collaborative digital painting experience designed for couples or close individuals separated by physical space. It allows two people to co-create art in real time using their heartbeats. One partner's heartbeat controls the color and stroke thickness, while the other directs the movement and speed of the brush. The canvas becomes a living, evolving artifact—one that reflects not only biometric rhythms but also a visual echo of two hearts beating across distance. What makes Pulse Paint special is that it cannot be created alone. Its existence depends entirely on collaboration, synchronization, and mutual presence—even when the participants are separated by thousands of miles. It is a living metaphor for intimacy: imperfect, spontaneous, and co-authored. Through it, a moment becomes a mark; a heartbeat becomes a hue; and a gesture becomes a shared memory.

This project holds profound personal meaning for me. It embodies my belief that design should not only solve problems but also honor emotion. It is also a testament to my journey as both a maker and a partner—someone seeking to bridge love and creativity across continents. Pulse Paint is my attempt to answer: Can technology speak in the language of presence? And if it must live on a screen, can it still feel like a heartbeat?



User Journey Map



Concept and Development

The concept of Pulse Paint emerged from a question that haunted me during countless evenings apart from my partner: how can emotional presence be co-authored—created together—even when two bodies occupy different geographies? I didn't want to design another tool that merely connected people. I wanted to transform communication into a shared act of creation—where two individuals, though apart, could produce something together that was uniquely theirs. Something alive.

The heart became the anchor. Its rhythm, always honest and always intimate, felt like the perfect source for this co-creation. From that realization, I envisioned a system where one person's pulse would dictate the brush's color and thickness, and the other's movement would guide its direction and speed. This separation of control made the experience inherently interdependent. Neither person could complete the painting alone. The artwork would only materialize through their mutual input—through the biological cadence of one and the expressive gestures of the other. This decision was deeply symbolic. Just like a relationship, the final image couldn't be dominated by one perspective. Instead, it had to be negotiated, spontaneous, imperfect—shaped in the space between two rhythms. Every stroke carries a trace of shared vulnerability, and every composition becomes a visual fingerprint of a specific emotional moment.

Bringing this vision to life meant navigating both technical and emotional design challenges. I experimented with a range of biometric sensors to capture heartbeat data and sought movement inputs that felt intuitive and unintrusive. But beyond responsiveness, the system needed to feel emotionally transparent. I didn't want the users to focus on the interface. I wanted them to feel like they were moving together—not across a screen, but across presence.

Pulse Paint stands at the convergence of art, intimacy, and interaction design. It taught me to frame presence not as a feature, but as a feeling—something living, shared, and embodied through collaborative motion. Through this project, I realized that when empathy guides design, even digital systems can become vessels for deeply human connection.

Contextual Research

Researching the Problem

The need for emotional presence in digital interaction is both scientifically validated and emotionally universal. Humans are innately social beings whose nervous systems are shaped by physical connection from infancy. Studies in affective neuroscience reveal that our brains respond to physical and sensory proximity with increased activity in regions associated with emotional regulation, empathy, and memory consolidation (Coan et al. 975). When these embodied cues—like holding hands, shared

breath, or the rhythm of another person's body—are absent, our ability to co-regulate and bond is significantly compromised.

The challenge becomes especially acute in long-distance relationships, where traditional modes of closeness are disrupted. While texting, video calls, and voice messages offer channels for communication, they do not fully substitute for the nuanced interplay of body language, shared physical rhythms, and synchronous emotional feedback. As psychologist John Cacioppo's research into social neuroscience suggests, emotional isolation—even when mitigated by digital contact—can still activate stress responses associated with loneliness (Cacioppo and Patrick 145).

What's more, studies in biometric entrainment—where two bodies align in physiological states—highlight how emotional closeness is often mirrored by physiological synchronization. Research by Helm et al. (2014) found that romantic partners who exhibit greater alignment in heart rate variability and skin conductance report stronger emotional bonds and mutual understanding. These findings show that emotional presence is not just metaphorical—it's measurable. Additionally, research in sensory deprivation has revealed the psychological toll of lacking touch and movement-based interactions. Studies indicate that when individuals are deprived of sensory input—particularly touch—it can lead to symptoms of emotional dysregulation, anxiety, and even depression (Gallace and Spence 447). This highlights the necessity of sensory stimulation in maintaining emotional equilibrium, especially in relationships where physical absence becomes chronic.

Emerging disciplines like affective computing and digital empathy design have attempted to address these emotional voids. Devices and systems now exist that attempt to simulate presence through haptic feedback or emotional AI recognition. However, many of these remain largely utilitarian or clinically focused, lacking the warmth, creativity, or poetic sensibility required to truly mirror human emotion in an expressive and relational way (Picard 15). Pulse Paint diverges from these approaches by offering not a solution, but a symbol—an artistic and collaborative ritual that bridges absence with creativity.

Pulse Paint is informed by this growing body of evidence, offering a poetic reimagining of presence where the heartbeat becomes not just a bodily signal, but a brushstroke. The project stands as a counterpoint to the flatness of digital communication. It doesn't aim to mimic a hug or simulate a call. Instead, it renders the invisible—your pulse, your shared rhythm—into something co-authored and alive, creating a sensory artifact of connection in real time.

Existing Solutions

Though Pulse Paint offers a uniquely biometric and symbolic experience, it joins a broader cultural and technological movement aimed at bridging emotional and spatial divides through shared digital spaces. Several collaborative platforms and tools have emerged over the past decade that prioritize togetherness, synchronicity, and co-creation—albeit through different modalities.

Real-time collaborative platforms like Magma Studio, Figma, and MURAL have empowered designers, artists, and remote teams to draw, annotate, and build together on shared digital canvases. These tools enable simultaneous input and offer a space where ideas and creative energy converge. While their primary purpose is professional or illustrative, the underlying theme is one of co-presence—of being able to act together in real time, regardless of geography.



Skribbl.io homescreen Souce: skribbl.io

In the entertainment and leisure domain, applications like Teleparty, Rave, and Scener let users synchronize video content and share reactions through text or voice while watching from separate locations. Though passive in nature, these platforms recreate the feeling of "being with" someone during a movie or show, mimicking the social rituals of in-person media consumption.

Social gaming environments like Skribbl.io and Drawasaurus take a more playful and interactive approach, offering participants the chance to co-create images or guess each other's drawings in real-time. The laughter, surprise, and spontaneity these games evoke underscore a key aspect of mediated togetherness: emotional contagion. In these moments, connection happens not through words alone but through actions, timing, and shared engagement.



Drawasaurus in action Source: gaunt.dev

Even productivity tools like Google Jamboard or other shared whiteboard apps are implicitly about shared presence—they allow people to leave visual traces for one another, build in tandem, and witness progress unfold collaboratively. What I believe all of these platforms underscore is a cultural craving to feel together, even when apart.

As mentioned earlier in this thesis, Virtual reality has also begun to explore immersive forms of co-presence, with platforms like VRChat, Horizon Worlds, and Second Life enabling avatars to interact in spatialized environments. Launched in 2003, Second Life was one of the earliest large-scale virtual worlds to explore identity, community, and presence in an entirely digital space. It introduced millions to the idea that human interaction could be rich, expressive, and socially complex in a virtual environment—foreshadowing today's metaverse discourse. While haptics were limited, the emotional bonds and social ecosystems that formed within Second Life proved the potential for digital intimacy long before VR became main stream.

Further, synchronous music collaboration tools like Endlesss and Soundtrap enable remote users to co-compose tracks in real-time. These platforms rely heavily on rhythm, emotional intuition, and mutual timing, not unlike the biofeedback mechanics at the core of Pulse Paint. They illustrate the rising popularity of using natural, embodied signals to fuel creativity across distance. Artists have also played a pivotal role in exploring biometric data as a medium of connection and presence. Rafael Lozano-Hemmer's iconic Pulse Room and Pulse Topology installations transform participants' heartbeats into immersive fields of flickering light, offering a poetic visual representation of collective presence and bodily rhythm. Similarly, Erin Gee's Project H.E.A.R.T. fuses biometric input with immersive soundscapes in



Secondlife Source: secondlifewiki.com



Meta horizon Source: Meta.com

VR, enabling a reactive environment that mirrors emotional states. Laura Splan's Metronome performance captures real-time biometric feedback and translates it into multisensory art, blending visuals, movement, and sound into a unified, bodily-aware expression. Heather Dewey-Hagborg's work, such as Stranger Visions, uses DNA data to create 3D portraits, sparking dialogue about identity and embodiment in the age of data.

Other artists have explored the deeply intimate and performative aspects of biofeedback. Lisa Park's Eunoia and Eunoia II used EEG headsets to translate emotional states into ripples on water, visually manifesting her inner psychological state as a meditative performance. Marco Donnarumma's work—such as Corpus Nil—uses biosensors and muscle contractions to control sound and visuals in live performance, pushing the boundaries of body-machine symbiosis. Daito Manabe has worked extensively with facial recognition and electrical muscle stimulation, turning biometric responses into rhythmic, often playful artistic performances. These artists challenge the viewer to consider not only the aesthetic of data but its emotional and ethical implications.

These artists elevate bodily data from the realm of the analytical to the symbolic, allowing it to express presence, memory, vulnerability, and intimacy. While some works are gallery-oriented and others speculative or critical, they share with Pulse Paint an interest in making the invisible visible—transforming internal rhythms and biometric realities into shared, externalized experiences. Pulse Paint thus extends and personalizes this tradition, offering an interactive, collaborative act between individuals that is felt, shaped, and remembered. Where these platforms and artistic explorations stop short, however, is in uniting collaborative art-making with real-time



Pulse Topology Source: wallpapermagazine.com



Corpus Nil Source: Ars Electronica

biometric input across geographical distance. This is where Pulse Paint positions itself not just as a tool, but as an expressive medium. It does not merely simulate collaboration; it enshrines connection into the visual language of pulse and gesture. By placing biometric data at the heart of its system, Pulse Paint invites users to not just draw with each other, but to draw from each other.

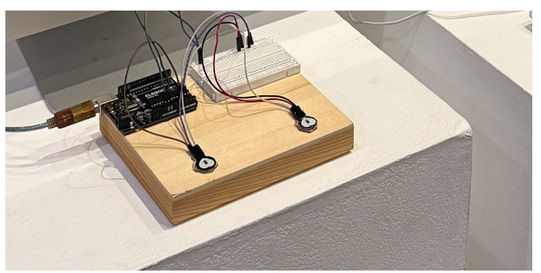
Design Process

The development of Pulse Paint was driven not by a linear plan but by curiosity, experimentation, and an urgent desire to create something immersive. Unlike my other projects, this piece was born from a spontaneous late-night idea just days before the first DMI Fresh Media show at the MassArt gallery. I wanted to explore something interactive, screen-based, and driven by real-time biological input—a departure from my prior tactile explorations.

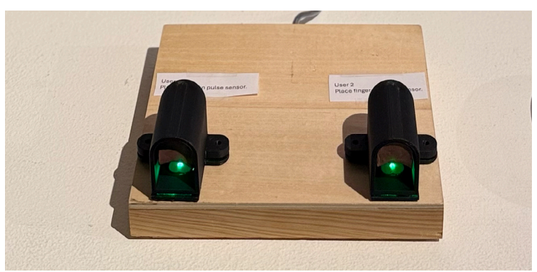
I recalled having two optical pulse sensors left over from my work on Huggables, and I paired them with an Arduino Uno R4 to start testing. I first verified the functionality through the Arduino serial monitor, confirming that each sensor could pick up stable heart rate signals. Once that was successful, I shifted to Processing and built the first visual sketch—a dual-input canvas on a screen, where one sensor-controlled the the thickness and color of a digital brushstroke, and the other controlled it's movement and speed.The initial prototype was an evolving, generative canvas where colors shifted in response to heart rate, and brushstroke properties were adjusted in real time. It also included a built-in reset feature that cleared the canvas when the spacebar was pressed, and a screenshot function that saved each session as a visual memory. This foundation would later be expanded, but even in this early state, the system demonstrated how a deeply personal signal like a heartbeat could influence and inspire co-created digital expression.

The sensors, however, were prone to noise and phantom readings, messing up pulse data, due to ambient light—a common drawback of optical sensing. Despite this, I mounted the exposed sensors, Arduino, and wiring onto a flat wooden base to gather initial user testing, giving it a touch of structure and mobility. This raw, unrefined prototype was showcased at the MassArt Fresh Media show. Despite its rough edges, it generated meaningful dialogue and emotional reactions further discussed in the user testing and feedback section. The visual simplicity gave way to powerful interactions, revealing the potential of biometric-driven shared creativity. After the show, I began refining the piece. For the second DMI Fresh Media showcase, held at Boston Cyberarts, I developed a more stable and visually clean setup. This iteration also introduced several visual and functional upgrades to the Processing sketch, including real-time BPM displays in the bottom corners and animated heart icons that pulsed in sync with each participant's live signal. I designed and 3D printed housing enclosures to shield the pulse sensors from light while improving comfort and consistent skin contact. These were mounted onto upgraded wooden bases for a more grounded, ceremonial interaction. While this version was still tethered to ensure performance in a gallery environment, it was far more polished and intuitive—featuring clear pulse-driven visuals, dynamic brushstrokes, color symbolism, BPM displays in the bottom corners, and animated heart icons reflecting each participant's real-time signal. Following that exhibition, I began developing a third and final iteration—one that prioritized freedom of movement and embodied interaction. This prototype introduced a fully wireless configuration using ESP32-C6 microcontrollers and the ESP-NOW protocol. Each user had a compact wristband designed to house the ESP32 chip and battery, while the pulse sensor, enclosed in a smaller 3D-printed shell, was strapped to the finger. This separation of sensing and processing enabled mobility without compromising comfort.

The wireless system transmitted heart rate data to a central receiver hub, which passed it to the Processing sketch in real-time. While elegant in concept, the wireless version occasionally suffered from latency and signal inconsistencies during testing. Because of this, I chose to exhibit the more responsive wired version at public events, reserving the wireless setup for private demos and further iteration. Today, Pulse Paint lives as a multi-phase project one that evolved from a last-minute experiment into a robust, expressive system for collaborative, real-time art. Each prototype added depth and clarity to the vision: that presence can be made visible, and connection can be rendered not through words or screens, but through shared rhythm, color & code.



The first prototype was showcased at FreshMedia, held at MassArt



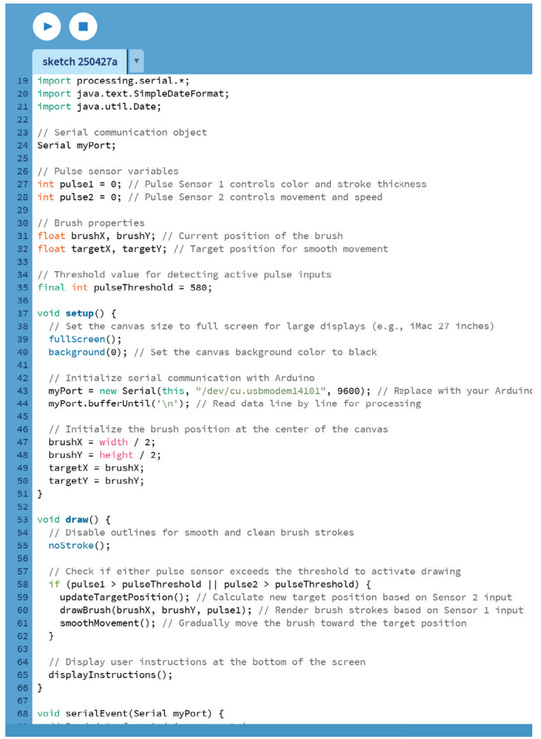
The second prototype was showcased at FreshMedia, held at the Cyber Arts Gallery

Arduino Sketch

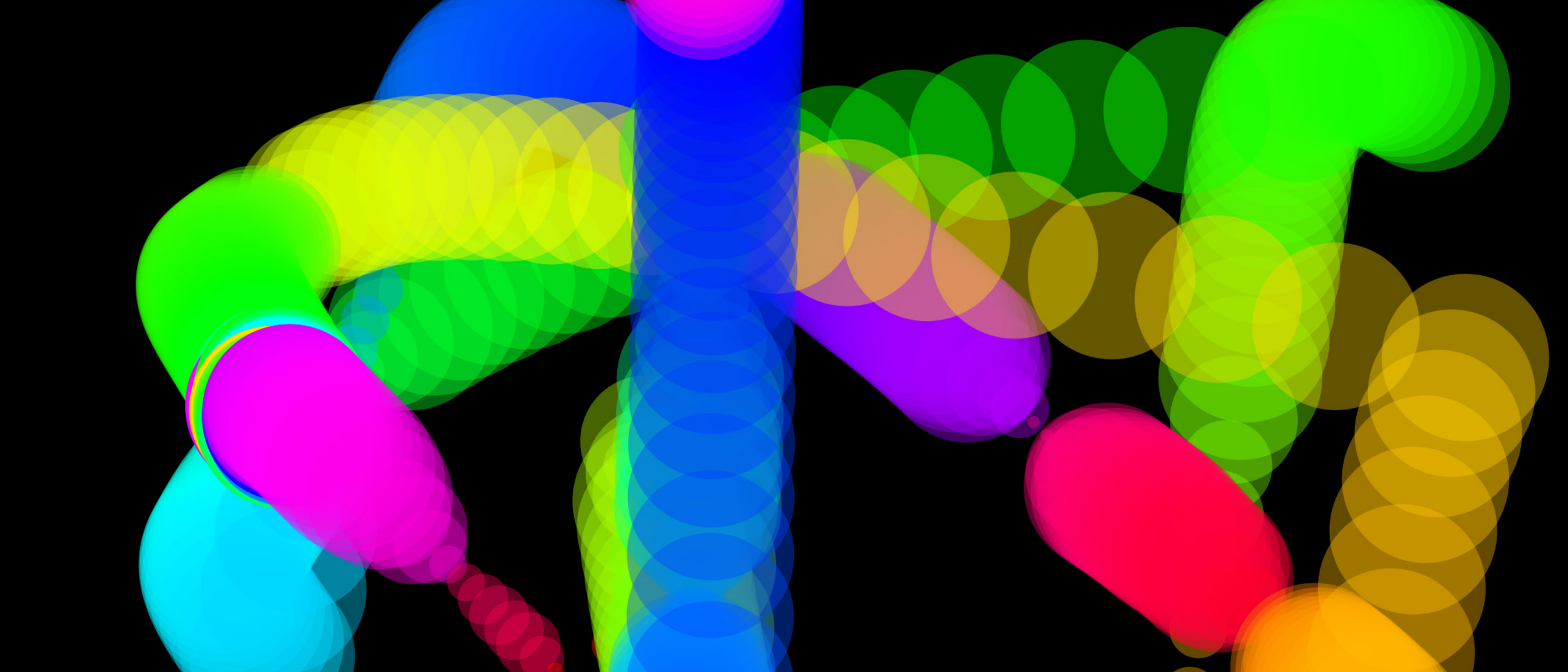


In this sketch, the Arduino reads two pulse sensors in parallel, prints their values to the Serial Monitor, and streams them over USB to a Processing sketch. In Processing, a custom algorithm tracks the variance of each incoming pulse stream and maps them to distinct visual parameters: one sensor drives the movement and stroke thickness of the brush, while the other adjusts the drawing speed and color palette.

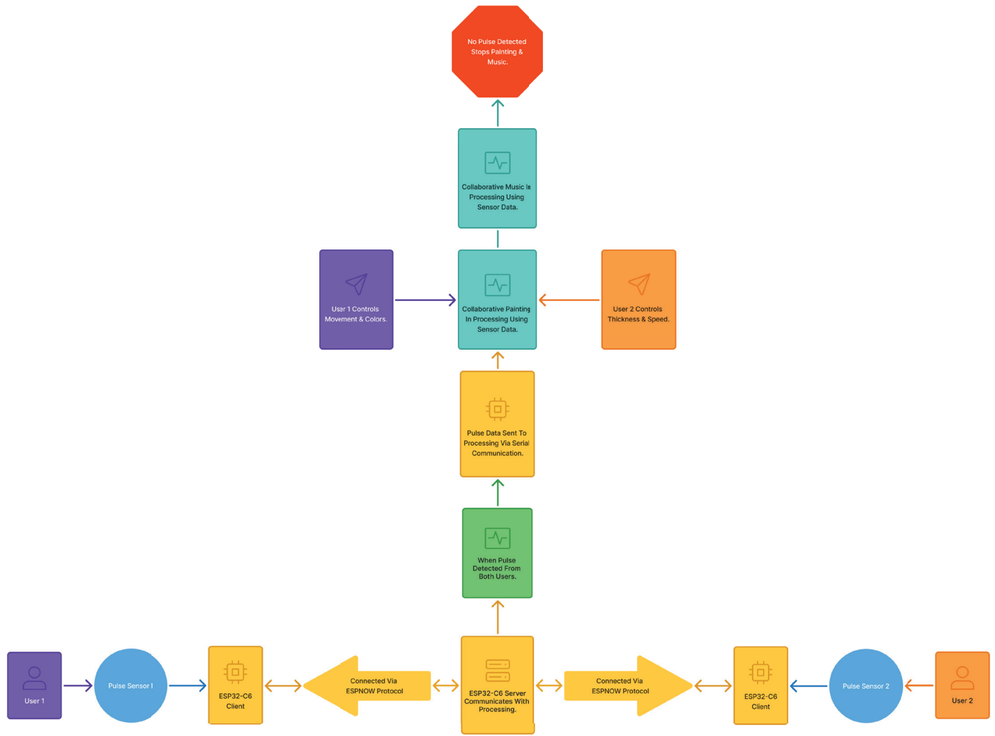
Processing Sketch



As each heartbeat arrives, these combined mappings generate a fluid, ever evolving artwork on screen that reflects the unique rhythms and interplay of both pulse inputs in real time.

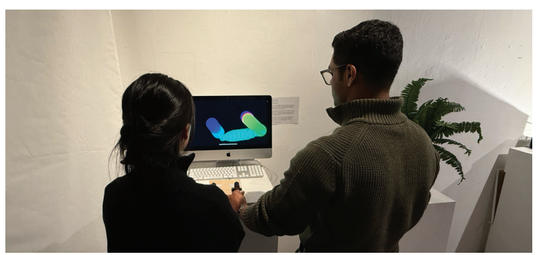


Hardware, Code Logic and Function



User Testing and Feedback

Pulse Paint made its debut at the first DMI Fresh Media show held at MassArt, where it was experienced by a wide range of participants—artists, designers, technologists, and casual visitors alike. Despite being conceived and built within a single night, the piece quickly captured attention for its quiet intimacy and biological symbolism. People were intrigued by the idea that their heartbeats—something deeply personal and internal—could be transformed into digital brushstrokes and co-authored artwork. This first iteration featured a raw setup with exposed sensors, Arduino Uno R4, and visible wiring mounted onto a wooden base. While visually unrefined, the prototype's simplicity gave way to powerful, affective interactions. The Processing sketch, though basic at the time, allowed users to paint collaboratively using their heart rates—one participant controlling the color and thickness of strokes, the other dictating movement and speed. Some users described the interaction as calming and meditative, while others found it intimate and emotionally stirring. A few called it a "visual duet," and several visitors paused to reflect on how the artwork became a metaphor for connection.



Visitors interacting with pulse paint at FreshMedia, held at the Cyber Arts Gallery

That said, some participants found the experience slightly uncanny. Externalizing such a private signal as a heartbeat made some feel vulnerable, as though the system laid bare something usually hidden. One participant remarked, "It's beautiful but kind of haunting—like it's too personal." This feedback confirmed that the piece wasn't just technologically novel; it was emotionally charged, challenging perceptions of data and presence.

The second round of user testing occurred during the second Fresh Media exhibition held at Boston Cyberarts. By this time, the project had gone through significant refinement. The sensors were enclosed in 3D-printed housings, and the Processing sketch had evolved to include enhanced visual feedback such as pulsing heart icons and BPM readouts. The wooden base setup remained for stability, and the wired connection ensured smooth, uninterrupted performance—an intentional decision to preserve responsiveness in a gallery environment.

This version received praise for its improved clarity, ease of interaction, and poetic visuals. A few participant testimonials gathered during the Boston

Cyberarts exhibition provide insight into how the work resonated. One viewer shared, “I’ve never felt so connected to someone through art. It’s like we were painting with our bodies.” Another described the experience as, “a heartbeat turned into a poem. Watching it unfold in real time was surprisingly emotional.” A third participant reflected, “I wasn’t expecting to feel seen by a piece of technology, but this made me pause and reflect on my own presence.” And another offered, “It’s interactive, yes—but it’s also reflective. It made me more aware of how I exist next to someone.”

Many visitors commented on how the system no longer felt experimental but intentional, crafted with care. Users still expressed a desire for portability, and several suggested turning the platform into an app that couples could use remotely. Others wanted a way to preserve their collaborative creations, which led to interest in the built-in screenshot function.Following the exhibitions, the third prototype—a fully wireless version—was tested extensively with peers and friends in more informal settings. This iteration featured a custom wristband to hold the ESP32 and battery, with the pulse sensor attached to a finger via a 3D-printed clip. Participants appreciated the freedom of movement, noting how the absence of wires allowed them to focus more on the interaction rather than the hardware. Some expressed that the wearable nature of the system made the experience feel more personal, as if their body had become part of the artwork itself. Others commented on how the wireless design hinted at its potential for real-world use—between long-distance partners or even in public installations.

A few testers did note occasional lags or dropped data in the wireless mode, but most agreed that the emotional effect remained powerful and the visual feedback remained compelling. Throughout all phases of testing, Pulse Paint sparked curiosity, conversation, and connection. It invited people to slow down, become aware of their bodies, and share space—digital and emotional—with another. Whether interpreted as meditative, eerie, or symbolic, the feedback consistently affirmed the project’s core ambition: to turn invisible rhythms into something you could see, share, and remember. It invited people to slow down, become aware of their bodies, and share space—digital and emotional—with another. Whether interpreted as meditative, eerie, or symbolic, the feedback consistently affirmed the project’s core ambition: to turn invisible rhythms into something you could see, share and remember.

Conclusion

My Journey in the Making

Pulse Paint began as an impulsive, late-night experiment—a product of curiosity, urgency, and a desire to test the emotional potential of real-time, biometric-driven interaction. Born in the final hours before a gallery show, its first iteration was raw, exposed, and deeply human. And yet, that vulnerability is what made it resonate. What began as a simple proof-of-concept evolved into a full-body, co-creative experience—an artwork that made people feel seen, connected, and part of something living.

What I Learned

The journey of making Pulse Paint was as chaotic as it was revealing. From debugging phantom sensor signals on a wooden base to designing custom 3D-printed housings and developing a wireless wearable prototype, I learned the importance of iteration—of letting a project guide you as much as you shape it. The process sharpened my skills in hardware-software integration, real-time data visualization, and interaction design, but it also taught me that the most successful pieces don’t just work—they feel. Technically, I learned how to translate biometric signals into visual outputs, how to build wireless communication systems using ESP32s and the ESP-NOW protocol, connecting multiple ESP32s in server-client and host-device relationships to ensure synchronized data flow and responsive interaction across separate modules, and how to balance aesthetics with stability in a gallery-ready setup. I built tools that responded not just to code but to heartbeat. More than that, I learned how design choices—like sensor enclosure, interface layout, or even stroke color—could impact a user’s emotional engagement.

The Outcome

The outcome is a work that sits at the intersection of intimacy and interactivity, simplicity and symbolism. It doesn’t aim to simulate closeness through screens but to make biological presence visible—to turn a heartbeat into a brushstroke and a moment into memory. With every prototype, Pulse Paint evolved further into an artwork that didn’t just depict connection but actively enacted it through design. From the physicality of its finger-mounted sensors to the richness of real-time visual feedback, the piece became an intimate performance co-authored by each participant. What emerged was not just an interface but a shared experience. The final visual canvas became a portrait of presence—a generative, living artifact shaped by human rhythms. By reducing the input to something as primal and poetic as a pulse, the system enabled an artwork that was simple in form yet deep in

meaning. It embodied the core ethos of my thesis: that technology, when designed for emotion rather than efficiency, can reconnect us to ourselves and to each other. Feedback from users strongly supported this alignment. One participant described the experience as “a moment where my body and another person’s rhythm became visible—we were creating without speaking.” Another noted, “It’s so rare that tech feels this human.

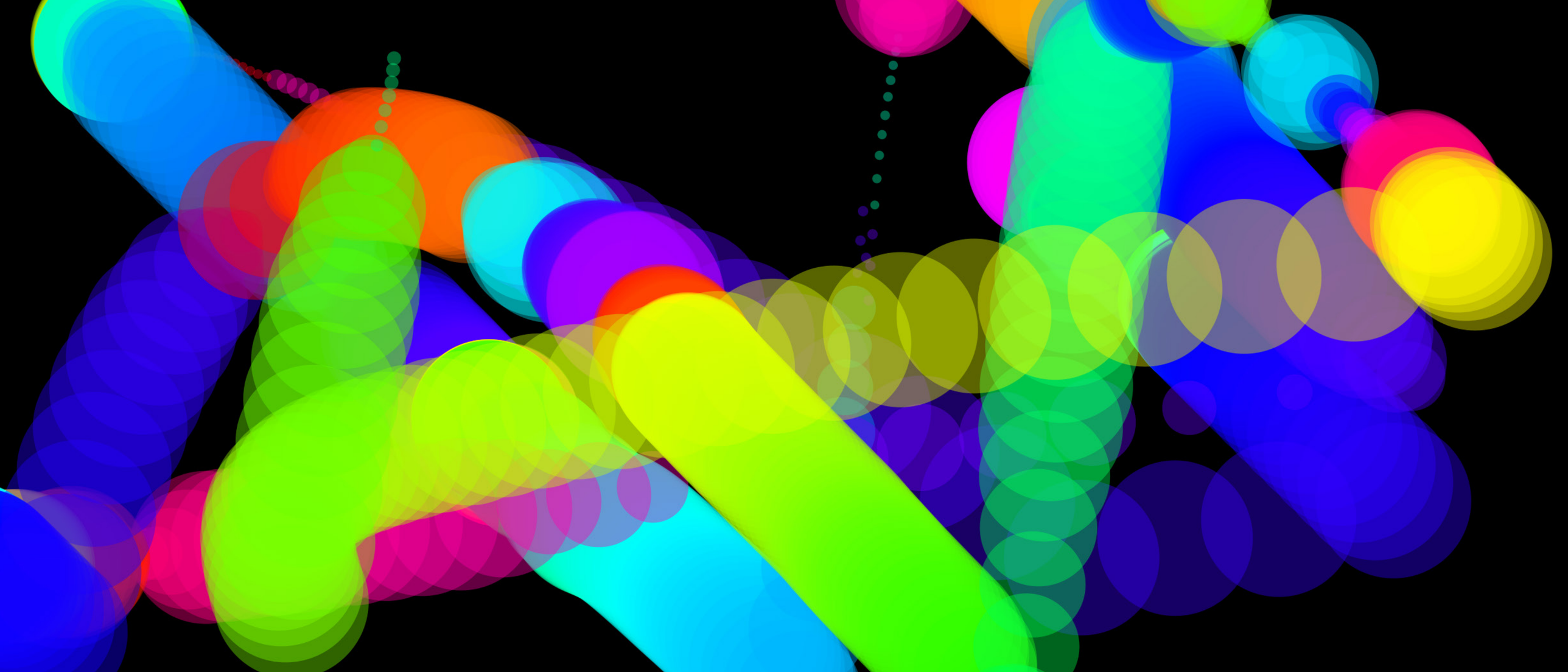
This made me feel grounded and seen.” These reactions confirmed that Pulse Paint wasn’t just functioning within the framework of my thesis—it was a living example of it. It stands as a tangible outcome of exploration and empathy—where the invisible is made visible and the personal becomes poetic.

The Future

Looking ahead, Pulse Paint holds potential for further development as a mobile or web-based platform for couples and collaborators in long-distance relationships. It could be scaled for public installations or adapted as a therapeutic tool in wellness settings. There’s room to refine the wireless model, introduce networked collaboration across locations, and customize visual styles based on shared memories or emotional states. Ultimately, this project is a reflection of my thesis: the desire to make distance feel less distant, to design experiences that help people feel connected not in spite of technology, but through it. Pulse Paint is my reminder that even the smallest human signal—a heartbeat—can carry enough weight to move, to connect, and to create.



Pulse Paint Showcased At Fresh Media



Mini Case Studies

These mini case studies were passion projects I dove into whenever I had downtime—whether during summer breaks or between larger projects with leftover parts. They proved invaluable for sharpening my hardware and coding skills, deepening the narrative behind my work, and even offering subtle cues that helped me solve larger problems in other projects.

Reminders

Reminders was a quiet little project that emerged during the in-between phases of larger thesis work—a kind of emotional experiment that turned into a surprisingly comforting ritual. It was rooted in the loneliness of everyday moments—the kind that creeps in not when you're doing something significant, but when you're just making tea or brushing your teeth and realize no one's there to call you out when you leave the cabinet open again—or leave the toilet seat up. This project became my way of bringing those small, familiar nudges back into my living space—those tiny but meaningful habits that define being around someone you love.

I built Reminders using an Arduino Nano 33 IoT, a compact microcontroller, and an ultrasonic sensor that detects distance using sound waves. Depending on the selected mode—cabinet or toilet—the Arduino monitors for an object within 0–3 cm and timestamps any change: in cabinet mode, as soon as the sensor detects an object in range it sends "0," and if the space remains empty for 30 seconds it sends "1"; in toilet mode it sends "0" immediately when no object is detected within 0–3 cm, and only sends "1" if an object stays in range for more than 30 seconds. A Processing sketch listens to this serial stream, looping a recorded audio message whenever it reads a "1" and stopping playback as soon as a "0" comes back. I later replaced the laptop with a mini MP3 player. The voice in those recordings was my wife's—playful reminders like, "Who's gonna put the spice jars back and close the cabinet?" and "Who's gonna put the toilet seat down?"—small, loving echoes from home. I designed and 3D-printed a small enclosure for the sensor to blend seamlessly into its surroundings, installing one inside a kitchen cabinet and another near the toilet so the system could run autonomously while I went about my day. Over time, I began forgetting the sensors were even there. Then, out of nowhere, her voice would gently cut through the silence—and it would stop me in my tracks. Each time, it sparked a smile, a laugh, a little moment of presence. It was like a memory tapping me on the shoulder.

Reminders didn't need to be complex or visually impressive. It was quiet, subtle, and deeply personal. It created emotional texture in my environment and allowed intimacy to sneak into my day in the most ordinary, ambient way. In the end, it reminded me of home—not by replicating it, but by catching me off-guard in all the right ways.



Testing reminders on a toilet seat



Emotional State was a quiet but curious exploration of how we might communicate feelings without words—using presence, distance, and subtle shifts instead of text or speech. The project built on the same foundation I had laid with Reminders. The hardware remained unchanged: an Arduino Nano 33 IoT microcontroller and an ultrasonic sensor, which uses sound waves to measure distance. But this time, I moved from Processing to Max 8 and re-imagined the interaction logic—shifting from binary signals to continuous distance data sent via serial communication. This change opened up a space for nuance, where emotion could emerge gradually rather than through on/off triggers.

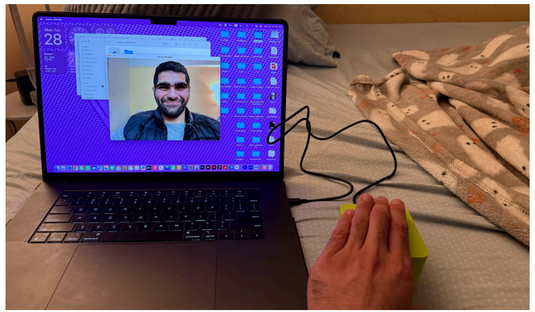
The premise was simple: how close or far you are from the sensor determines which version of my face you see on screen—and what emotional state it reflects. I photographed myself embodying a range of feelings: happiness, sadness, confusion, agitation, and anger. Each of these portraits was layered from high to low fidelity. At close range (0–5 cm), a crisp, happy image appeared. From 6–10 cm, the expression shifted to neutral. Between 11–15 cm, the portrait began to blur and soften, showing sadness or confusion. Finally, at 16–25 cm, the image grew distorted, pixelated, and emotionally intense—agitated or angry, depending on the distance. This project asked a quiet question: can we communicate emotion through the simple act of standing near or stepping away? It was inspired in part by how we use emojis in digital conversations—how those tiny icons can speak volumes without any actual words. Emojis are essentially emotional stand-ins, and I began to wonder: what if we could do something similar, but with facial expressions and proximity? What if emotion could be shared not just through symbols, but through movement, silence, and space?

Designing this was a very personal and reflective experience. I tested it on myself—walking toward and away from the sensor, watching my own face change on screen. Seeing my image blur and grow distorted as I moved farther away felt strangely real, like watching a reflection of my inner world shift based on my physical presence. It made me wonder how this could be used for others—especially for people in long-distance relationships or those who find it difficult to put feelings into words. Maybe this could offer a new language for emotional check-ins: subtle, symbolic, and felt.

I also started thinking about potential directions for future development. What if this system wasn't just one-way? Imagine two people, each with their own sensor and display, sending portraits back and forth in real time as emotional postcards. These wouldn't be static images, but living expressions of presence and mood, updated simply by moving through space. Whether delivered through an app, a shared screen, or even projected onto a wall, the possibilities felt expansive.

Emotional State wasn't meant to be a finished product. It was more of a sketch—an emotional proof of concept. But it stayed with me, because it helped me rethink how we interpret emotion in digital spaces. It made me realize that sometimes, we don't need more data—we need more feeling. In a world overwhelmed by constant communication, this project felt like a whisper. And maybe that's exactly what made it meaningful.

CutiBot was born out of curiosity, a touch of nostalgia, and the urge to give new meaning to a handful of unused components. During the 2024 winter break, I gathered leftover parts from earlier thesis explorations—Digital Embodiment, Huggables—and began piecing together something playful and expressive. At its core, CutiBot is a cubist-style, four-legged bedside companion, built to respond to emotional connections through simple, animated gestures.



Testing emotional state's early prototype



The ultrasonic sensor drives both the on-screen emotional-state display and the reminder audio logic.



Emotion 1 triggered at 0-2CM



Emotion 2 triggered at 2-4CM

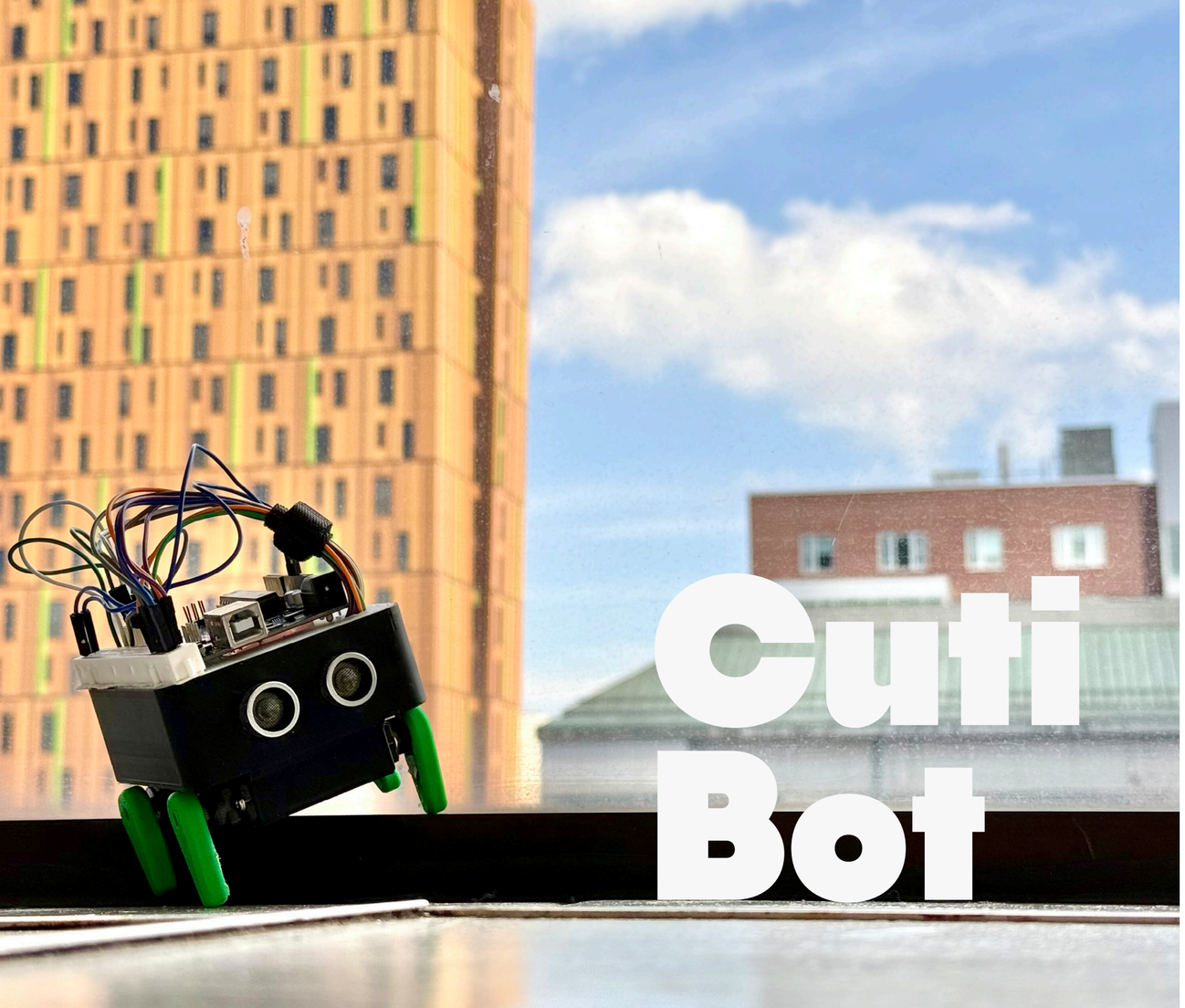


Emotion 3 triggered at 4-6CM



Emotion 4 triggered at 6-8CM

In Processing, the sketch displays one of four emotional states on screen—ranging from a happy face when your hand is near the sensor to progressively sadder faces as it moves farther away—based on the ultrasonic sensor's distance readings.



Cuti Bot

The project was also a personal return to form. In high school, I was deeply involved in the robotics club, and the hands-on joy of building machines that could sense, move, and react stayed with me. With CutiBot, I revisited that early passion through a new lens—one grounded in emotional design and the complexities of long-distance relationships.

Built around an Arduino Uno and programmed in the Arduino IDE, the bot features four 9g mini servos—one for each leg—that allow it to perform expressive, physical motions. It can bounce in place, rock gently back and forth, wave, or sit on its front or back legs. Each motion was designed not just for functionality, but to suggest mood and presence—like a body language sketch in motion.

The shell was 3D printed using my first printer here in Boston, a Bambu Lab model. I came across a pre-designed bot form through the printer's companion app, Handy, and while I didn't model the outer body myself, I customized and adapted it to house the electronics and support my own code and functionality. The result was a geometric, characterful form with an ultrasonic sensor embedded in the head—its "eyes"—giving it an approachable, curious look.

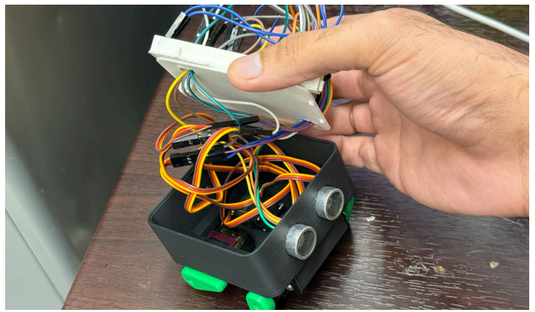
What made CutiBot especially meaningful in the context of my thesis was its speculative role in bridging emotional distance for people in long-distance relationships. The idea was for the bot to be paired with a phone via Bluetooth, and to react with different gestures based on who the notification was from. I imagined a joyful bounce for my wife, a calm sway for my mom, something cheeky for my sisters, and a grounding motion for my dad. It was about assigning emotional value to movement—creating a bot that could physically acknowledge a message in a way that felt personal and alive.

This part of the project remained speculative. While I successfully programmed CutiBot to perform its movements and gestures, I wasn't able to implement Bluetooth-based notification recognition. The bot couldn't yet distinguish between senders or trigger actions based on specific messages. That technical limitation left the idea unfinished—but not forgotten.

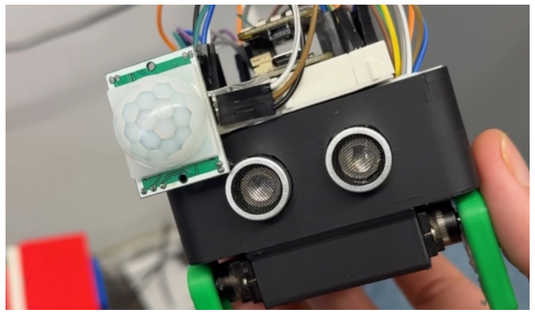
Still, the gesture was there. The intention was there. And that, in many ways, is the point. CutiBot may not have achieved its full vision, but it became a space to prototype presence—a quiet, nonverbal substitute for digital connection. Unlike screen-based notifications or sound alerts, its small motions offered something gentler and more human-like. It wasn't flashy. It didn't talk. But it moved—and that movement meant something.

Within the broader narrative of my thesis, which explores how design and dynamic media can create a sense of closeness across physical separation, CutiBot served as a symbolic stand-in for presence. It didn't aim to simulate conversation—it aimed to embody it. And even as an unfinished experiment, it

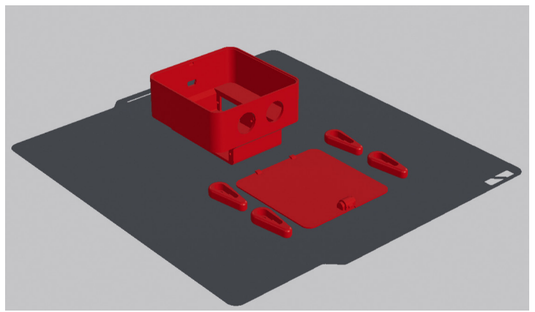
served as a meaningful reminder: sometimes, feeling connected is less about what's said, and more about what's quietly felt.



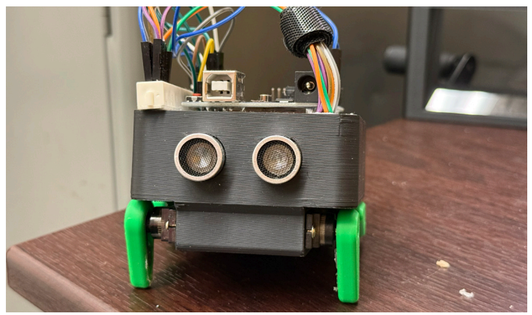
Guts of cutibot



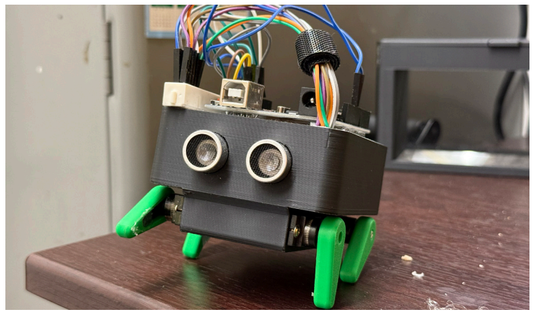
CutiBot's earlier Prototype with a motion sensor to activate gestures when motion detected



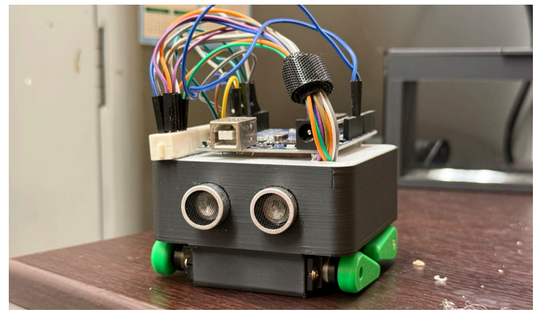
CutiBot 3D model CAD by Luca Dilo



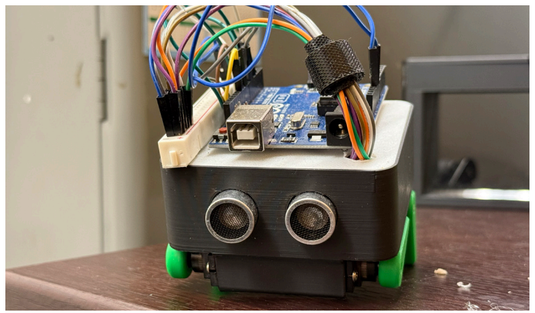
Cutibot leaning back



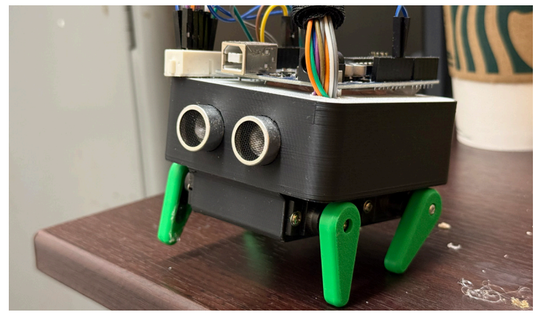
Cutibot waving



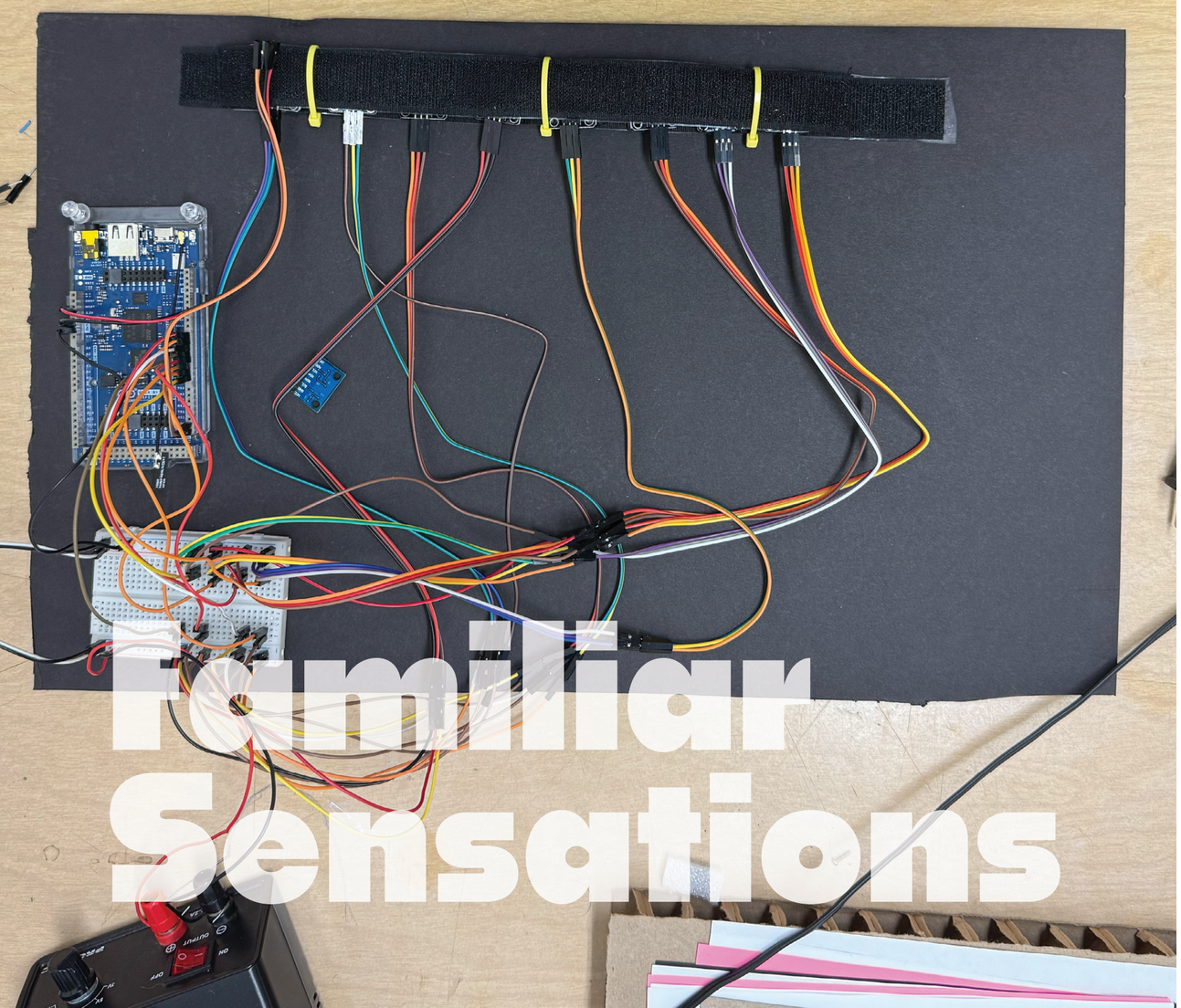
Cutibot sitting



Cutibot leaning forward



Cutibot moving



Familiar Sensations

Familiar Sensations emerged during the early phases of my thesis research, when I was collecting responses through open-ended and multiple-choice surveys. A pattern kept surfacing: people in long-distance relationships often said that while video calls and voice chats helped bridge the gap, what they missed the most was physical presence. They longed for the ability to feel their loved one's touch—something warm, soft, and human that could never be replicated through a screen. This insight aligned with findings from my contextual research: scientifically, nonverbal communication—including physical touch—is vital to emotional closeness. It was something I had been feeling personally as well, and it became clear that touch needed to be at the core of at least one of my experiments.

Inspired by haptic gaming gear—particularly jackets and remotes that simulate the feel of in-game action—I started wondering: what if we could repurpose that same technology to reintroduce emotional, affectionate touch between people separated by distance? What if a gentle caress could travel through space, not as a vibration of your phone, but as a tactile, intentional gesture? That question led me to create Familiar Sensations.

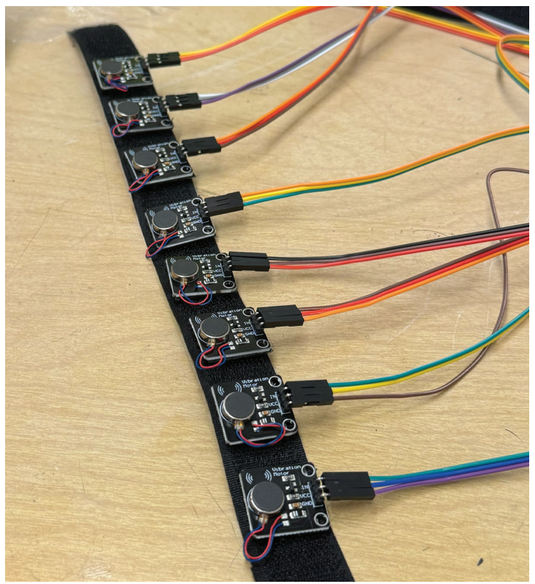
The prototype was built using an Arduino Giga, an MPU-6050 accelerometer sensor to track motion, and a set of vibrating disc motors to deliver haptic feedback. Everything was programmed using the Arduino IDE. When the sensor detected specific gestures or motions—like a soft stroke or a slow tilt—the motors activated in a wave pattern designed to mimic the sensation of a gentle caress. The first version of the device was assembled on a simple black rubber strip. Later, I upgraded the build by embedding the components into a layer of latex tattoo practice skin, and I created a custom 3D-printed project box to house the electronics securely.

From a technical standpoint, it worked. The system could detect movement and respond with reactive feedback. But emotionally? It didn't fully land. When I user-tested the prototype, the reactions were mixed. Most people struggled to interpret the feedback as touch. The sensation felt unfamiliar or unclear, and the emotional depth I hoped to convey through the caress-like motion wasn't coming across. The concept made sense to me, because I was building from my own emotional framework—but for others, it felt more like a tech demonstration than an intimate exchange.

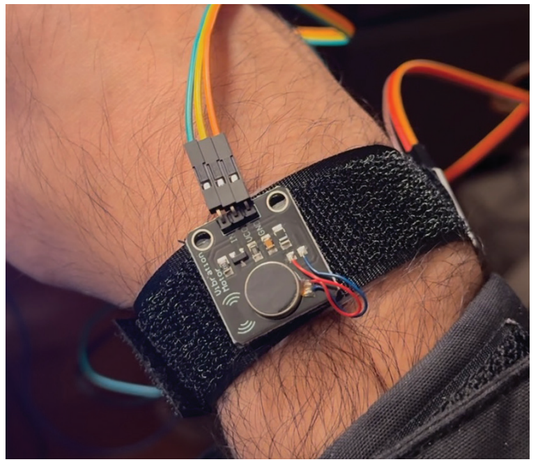
At that point, I decided to put the project on ice. Other thesis explorations were evolving more fluidly, and Familiar Sensations began to feel more like a conceptual sketch than a viable solution. Still, the time I spent working on it wasn't wasted. In fact, it became foundational in helping me understand the technical behavior of the MPU-6050 accelerometer—knowledge I carried forward into Digital Em-

bodiment. That experience allowed me to design a more accurate and reliable motion-tracking system, ultimately improving the emotional resonance and performance of that piece.

Not every experiment needs to be finished to matter—some exist to help us ask better questions and find other solutions.



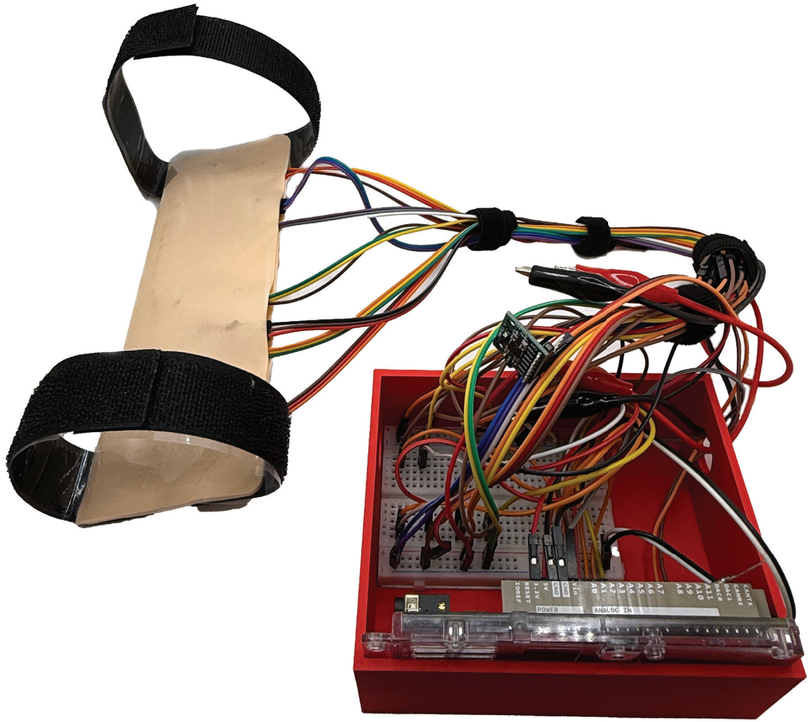
Haptic motors that mimic the sensation of touch



A variation in placement like a wristband



Fred Wolflink testing out initial Prototype at FreshMedia



In its final iteration, I replaced the band with a latex pouch to more closely mimic skin-to-skin contact, 3D-printed a robust enclosure for the microcontroller, and ultimately paused work on the project due to time constraints and the overall scope of the project.



Love Quest

The Love Quest Game was created as my final submission for the Fundamentals of Game Design course at MassArt, and it marked my first experience working with Unity. It was more than just an assignment—it was an opportunity to extend the emotional and narrative themes of my thesis into an interactive space. Since I was already exploring long-distance relationships through physical and emotional presence, I began to think: what if love itself became the core mechanic of a game? What if play could be a medium for closeness?

The game is designed as a two-player experience—specifically for couples in long-distance relationships. One partner becomes the game's storyteller, responsible for hiding three treasure chests in an open-world environment and assigning a custom multiple-choice question to each one. The other partner plays the game by exploring the virtual world, searching for the chests, and answering the questions. If they answer correctly, they receive a key. If they choose the wrong answer, they must restart from the decision point—but their previously earned keys remain. Once all three keys are collected, the player can unlock a final grand chest containing a surprise crafted by their partner. This could be a heartfelt note, a photo, or a message meant to evoke shared memories or intimacy.

The intention was to design a simple, emotionally driven quest that brought couples closer together through personal storytelling and light puzzle-solving. At its core, The Love Quest Game invites couples to build trust, test how well they know each other, and create moments of joy—even across distance.

I built the game in Unity using a pre-built terrain as a base, and then modified the environment, created custom objects like the rustic, aged keys, and designed riddle screens that used floral motifs—a symbol of love and affection. The color palette was intentionally soft and warm, and I included instrumental music to create a calm, nostalgic atmosphere. These decisions were meant to guide the emotional experience, making the game feel intimate rather than performative. Given my beginner-level experience with Unity, I couldn't fully realize the multiplayer functionality or build a fully customizable game engine. What I created was a visual demo that communicates the game's concept with preset locations, questions, and a single final surprise. However, even in this limited state, it reflected what I wanted to achieve: a game that feels like a love letter you get to play.

Looking ahead, The Love Quest Game has the potential to evolve into a rich, deeply customizable platform. I envision future versions with multiple levels, player-designed maps, personalized music uploads, and the ability to store shared memories. Couples could co-create their own worlds, layering their stories into the game environment over time. I'm also interested in integrating biometric data—

like pulse sensors—into the gameplay. For example, one speculative mechanic could involve the player's heartbeat: if the game detects your pulse, you can move; if your heartbeat drops or isn't detected, the character "fades" or "dies" until connection is reestablished. This could add a poetic layer to the game—tying presence, aliveness, and emotion directly into the mechanics.

In many ways, this project became a bridge between my thesis research on intimacy and the language of interactivity. It was playful, but meaningful. Personal, but shared. And while it's still in a developmental phase, The Love Quest Game gave me a chance to explore how design, emotion, and storytelling can come together—not just to entertain, but to connect.



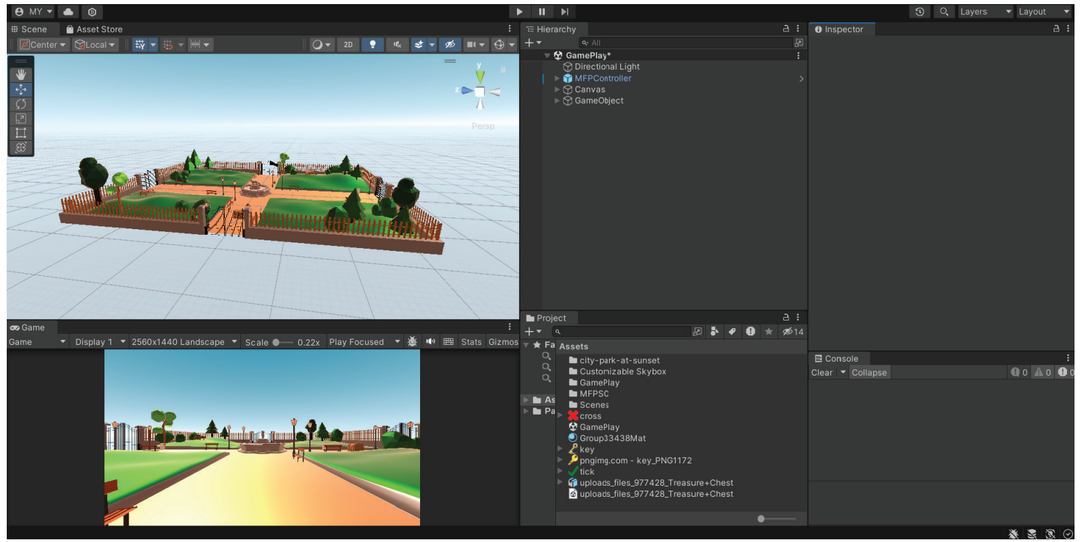
The collectible key that unlocks the chest

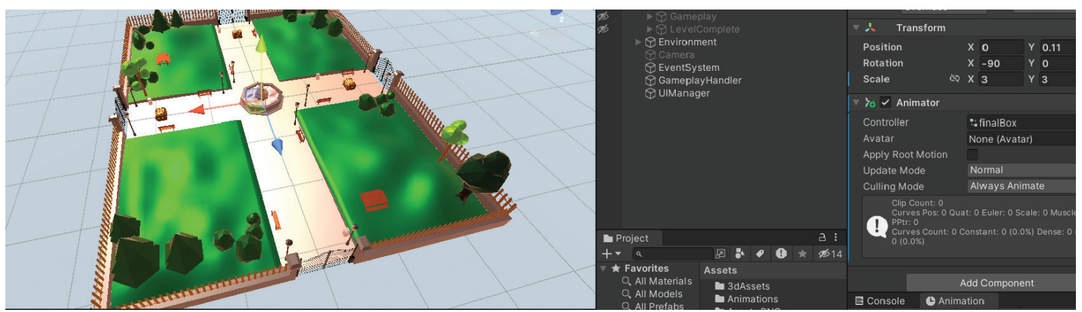


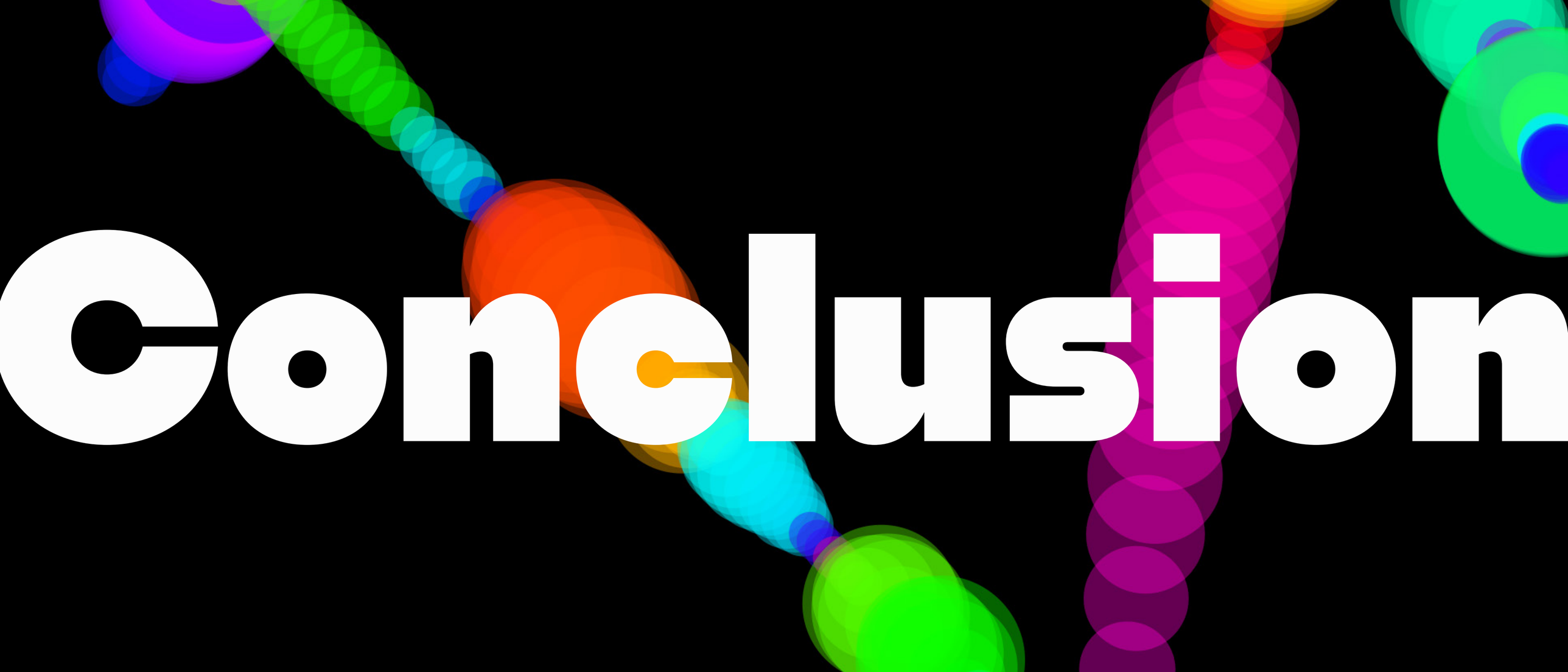
The grand chest that contains the memory



Riddle pop up screen






Conclusion

This book began with a question born of personal longing: How do we stay emotionally close when we are physically far? What unfolded was a deeply personal, creatively rich journey—a multidisciplinary exploration of presence, intimacy, and human connection. Through each prototype, I tested the emotional gravity of absence and the quiet power of presence—not merely as something seen or spoken, but as something felt.

Working with scent, motion, sound, and touch, I discovered that the smallest sensory cues can carry tremendous emotional weight. A faint aroma, a gently shifting sculpture, a pulsedriven brushstroke—each served as a building block of simulated closeness. They reminded me, and those who experienced them, that connection is less about proximity and more about resonance: the instant a sensory signal in one body finds an echo in another, collapsing distance into shared feeling.

My understanding of resonance deepened in Boston at MassArt's Dynamic Media Institute. The city's layered character—Revolutionera brickwork beside glasswalled labs, afternoon sketch sessions at the Museum of Fine Arts (MFA) followed by talks at the Institute of Contemporary Art (ICA), and openstudio walks in SoWa—supplied constant inspiration. Boston showed me how art and engineering can share the same street, and how curiosity, when paired with craft, becomes practical experiment. Weekly critiques with classmates from diverse backgrounds sparked conversations that stretched well beyond the classroom, while openmic nights in local cafés and collaborative popups in Fort Point connected me with painters, musicians, and technologists whose perspectives folded into my work—turning every prototype into an act of cultural exchange.

I arrived as a visualcommunication designer versed in moving images, typography, and narrative, but MassArt pushed me to think in sensors and data, weaving code and circuitry into experiences that remain unapologetically human. Latenight soldering sessions in the electronics lab and serendipitous chats at MIT Media Lab with generous engineers helped refine my projects. With each prototype my toolkit widened—from Python, C++, JavaScript, Max, Processing, and 3D modeling to a growing fluency in soft materials, scent diffusion, and haptics—while my capacity to listen—to user feedback, embodied memories, and the subtle signals of longing—deepened. That iterative education transformed me from a graphic designer into a creative technologist, comfortable translating abstract emotion into tangible, multisensory experience.

Between prototypes and critiques, I lived the very separation I was trying to heal—morning calls spanning time zones, birthdays and anniversaries compressed into pixelated screens. Then, in my third semester, the visa barriers finally lifted. When I greeted my wife Maha and our daughter Mirha at Boston Logan Airport, the theory of presence became real in my arms. As I write these pages, their footsteps echo in the next room—living proof that the questions driving this work are worth asking.

Outcomes

I came into this with a personal story and a burning question, and what emerged were five functional, emotional, and critically thoughtful projects that explored a multisensory approach to human connection.

Digital Embodiment uses synchronized motion paired with a familiar scent to evoke the comforting presence of a loved one, Huggables employs haptic feedback to mimic the gentle pressure of a warm embrace. Pulse Paint transforms the rhythm of a heartbeat into collaborative visual art, inviting participants to create together. Reminders reintroduces auditory cues reminiscent of everyday home life—subtle sounds inspired by the intimacy of familiar routines. And finally, Emotional State uses a gesture-based system to translate nuanced emotional expressions into tangible signals, conveying feelings that extend beyond words.

Through these varied prototypes I traced consistent patterns in how people engaged with multisensory cues. When visitors slipped on the Digital Embodiment sensor, many exaggerated their movements, laughing when the stacked cubes echoed each gesture; a handful stepped back, noting that the scent burst felt startling at first. Because the prototype wasn't yet truly huggable, most visitors simply rested a hand on top of Huggables, feeling the warmth, gentle vibration, and subtle riseandfall of simulated breathing; a few still described the sensation as uncanny, reminding me that comfort has a narrow bandwidth.

With Pulse Paint, partners quickly learned to "speak" by speeding or slowing their heartbeats; some delighted in that silent dialogue, while others hesitated at the intimacy of sharing biometric data. Most users mastered Emotional State within minutes, intuitively realizing that handtosensor distance was itself the emotional dial—closer meant "I'm happy," while pulling away communicated sadness—letting them express feeling through nothing more than spatial gesture

These mixed reactions—curiosity, delight, hesitation—proved just as instructive as outright praise. They taught me that presence is negotiated, not prescribed; that intensity, timing, and context can turn the same stimulus from comforting to uncanny; and that emotional technology must make space for individual thresholds of comfort, privacy, and meaning. People left imagining practical uses that stretched well beyond the gallery—from easing longdistance relationships and supporting elder care to mitigating pandemic isolation and enriching therapeutic practice. Their projections confirmed

that the desire to feel someone's presence transcends circumstance and culture. Together, these projects challenge the notion that mere visual and auditory connectivity is enough. They advocate for engaging four out of the five senses—touch, sound, sight, and smell—to evoke memories, stir emotions, and recreate the rich, nonverbal language of physical presence. In doing so, they highlight the indispensable role of sensors as a critical bridge between our physical and digital realities, capturing delicate cues and turning them into interactive, sensory-driven experiences.

What I Learned

Designing for human emotions is an unpredictable, humbling, and deeply personal experience. One of the biggest lessons I learned is that every human being carries a distinct emotional landscape—formed by culture, memory, upbringing, relationships, and life experiences. While there are shared needs like love, presence, and belonging, the way these emotions surface is highly individual. That realization showed me I couldn't design a single solution for everyone. Instead, my work must meet people where they are and create space for personal connection.

It also revealed the importance of designing with—not just for—people. During user testing I saw how one artifact could be playful to one person and poignant to another. Comfort for one participant echoed loss for someone else. These reactions didn't discourage me; they guided me. They reminded me that successful design is never neutral—it is alive, responsive, and emotional.

This thesis became an intense crash course in creative technology and physical computing. I learned to code in Python, C++, and JavaScript, each language unlocking a different layer of interactivity. Working with Arduino and other microcontrollers, I grew confident wiring sensors and building embedded systems that sense, interpret, and respond to presence in real time.

I dove into Max/MSP and Processing, translating raw data into motion, light, and visuals that feel alive. These tools pushed me to think in systems and causeandeffect loops, where a subtle gesture can set off a cascade of sensory outputs.On the physical side, I honed my 3Dmodeling and printing skills with Shapr 3D and Tinkercad, developed custom enclosures, and experimented with materials—silicone, latex, foam, textiles, acrylic, wood—to find the right tactile and emotional qualities for each prototype. Building quickly and iteratively taught me to troubleshoot not just code but the behavior of the physical world. Together, these explorations gave me a toolkit both wide and deep. I entered the program as a visualcommunication designer; I graduate as a multidisciplinary creative technologist who can code, prototype, engineer, and empathize. That shift changed not only how I work but how I think: my design process now bridges emotion with computation, visuals with mechanics, aesthetics with empathy.

It was also a crash course in human nuance. I learned to ask better questions and listen—not just with ears but with attention. Collaborating with classmates from varied belief systems and artistic traditions expanded my emotional intelligence and reframed my understanding of distance, connection, and belonging. I didn't just become a better designer—I became a more intentional thinker, a more patient problemsolver, and a more emotionally literate human being. I began this journey trying to understand distance; in the process, I discovered depth.

The Future

This is just the beginning—both for these projects and for me as a designer committed to bridging emotional gaps through technology. I intend to continue refining the technical and emotional foundations of each prototype, pushing them beyond the realm of conceptual art into scalable, accessible tools for everyday life. Whether that means launching a Kickstarter or Indiegogo campaign, collaborating with engineers, or partnering with therapists, technologists, or even fragrance specialists, my goal is to bring these human-centered technologies into homes, hospitals, care facilities, and long-distance relationships around the world. I envision Digital Embodiment being installed in homes and personal spaces, offering a real-time sense of movement and presence to loved ones living apart. I see Huggables becoming a therapeutic tool for couples, elderly care, or even stress relief—reimagined in plush or wearable formats. Pulse Paint could evolve into an interactive mobile app or gallery installation, allowing users to create long-distance art in real-time. Reminders might take the form of ambient smart speakers that play personalized soundscapes based on who you miss and when. Emotional State could become a wearable that captures and conveys affective gestures with vibrational or color feedback.

Beyond the products themselves, I hope to contribute to a growing conversation around emotional technology—not just smart tech that reacts but feeling tech that resonates. I want to continue publishing, speaking, and collaborating with others at the intersection of design, human-computer interaction, and mental health. I see myself prototyping, teaching, mentoring, and consulting on how we can design for feelings as much as for functions.

In 2025, as we face continued global migration, the emotional toll of displacement, remote work, and fractured relationships, these tools feel more urgent than ever. The lingering aftermath of the COVID-19 pandemic has reshaped how we understand presence, redefining intimacy and care in an era of touchless interaction. Add to that the volatile political climate in the United States—with

immigration debates, border anxieties, and increasing societal fragmentation—and the need for emotionally intelligent design becomes not just timely, but essential. We are witnessing a paradox: we've never been more digitally connected, yet rarely have we felt so emotionally distant. Video calls, texts, and digital presence help us maintain contact, but they fall short in restoring the warmth, spontaneity, and subtlety of in-person connection. That gap—between what is shared and what is felt—is the space I want to design into.

We need new rituals of closeness. New ways to smell a familiar memory, hold onto an absent heartbeat, and sense presence even when bodies can't cross borders. If I can continue to play a role in designing those tools—tools that turn absence into presence, longing into interaction—I will. Because the future of design isn't just digital. It's human. And even when we're far apart, we still deserve to feel close.



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