Technically Touchable / Tangible Future

Lu Bing's Portfolio 2022-2023

CONTENT

- Design Project: **Technically Touchable** series is a series of research on soft robotics and **haptic communication** between human & robot and human & human.
  Collaborated with Pranayit Myadam and Julia Zhu.

A research on diverse layers of materiality in embodied experience, to draw a picture of a more tangible future in this increasingly digital world.

This research shows how tangible media with an emphasis on haptics has greater potential to restore the uniqueness and authenticity of embodied experiences, leading to the future of **human-material interaction** where reality is enhanced rather than replaced.

Touch


PHENOMENOLOGY OF PERCEPTION
MAURICE MERLEAU-PONTY
In the perceived physical world, we inhabit our bodies, living with them and with all their perceptions as the primary site of knowing and experiencing.
Can we build connections between human and machine through touch?
Touch ⇄ Haptics communication is a direct and efficient way to build connections, & evoke emotions and memories.

Illusory Perception Study

We were interested in testing the connection between vision and touch and the subsequent effect it has on haptic perception. To test this we conducted a study inspired by the Rubber Hand Illusion and added more layers of materials and movements.

The rubber hand "illusion" (RHI), in which participants report experiences of ownership over a fake hand, appears to demonstrate that subjective ownership over one's body can be easily disrupted.

In addition to stroking and striking the fake hand with the ruler, we experimented with contrasting visuals, textures and temperatures.

ORIGINAL RULER TEST

The fake hand is struck with the ruler, and if the subject has been successfully immersed, they will flinch, or be scared since they think its their own hand being hit. However if the immersion is not deep enough, this will not be successful.

For the ruler hitting test, Subject 1, 3, 4 and 5 expressed that they almost pulled their hand back or got scared, while the others were not as affected.

CONTRASTING TEXTURES AND MATERIALS

On the fake hand we used a soft, fake fur hat while on the real hand we used a spiky roller to test if we could make people change their pre conceived perception of what the hat would feel like.

General Feedback: Enjoyed the contrasting feeling more than expected.
Question: If done in reverse, could we convice the users that the spiky roller they see is not dangerous but making them feel a softer sensation

CONTRASTING TEMPERATURES

To test if contrasting temperatures could affect perception, we used an air pump on the fake hand and a zip bag filled with ice cold water on the real hand.

Key Feedback: Sound of wind affects perception

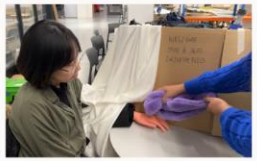
Subjects mention that they feel confused because what they see and what they feel is different.

SIMILAR SENSATION OR ACTION ON EACH HAND BUT DIFFERENT MATERIALS

On the fake hand we used wool to poke whereas on the real arm we used a pointed cable.

Key Feedback: Synchronised movement makes it more believable.

Subject 5 expressed that when the action on her real hand is stopped (but still continues on the fake hand), the sensation continues, but gradually fading each time.



Conclusion of Concept

From these research and studies, we concluded that we wanted to explore the potential of haptic communication and movement in evoking visceral reactions and emotions. We were also interested in pursuing contrasting visuals to further alter touch perception and exploring the alternative and radical when it comes to touch.

Prototyping and Design Iterations

As the nature of our project is that of trial and error and trial again, we'd like to prepare you before we dive into the numerous versions of mechanisms we have tried and tested, as they are part of the important journey that has resulted in our final installation. Each of these versions has provided useful insight that we carried over to the next version or have revisited at some point.

Letsgooooooooo

Mechanism Testing

grabbing ---- ---- ---- ---- ---- *curving*

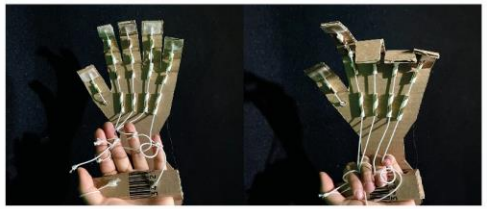
rigid mechanism

Fully-Rigid Gripper.
It can only achieve grabbing movement.
The tactile sensation is hard, sharp and non-human like.

ref: Curling Kinetic Spiral by John Edmark

Rigid Structure but can create a relatively more adaptive and more lively enclosing movement. Yet not very structurally stable when adding weight.

rigid mechanism + tendon cable



Extended Arm.
the tendon cables make it more controllable. Yet mutiple forces needed.

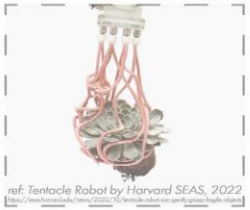
Basic Kinetic Unit
of the extended arm

soft mechanism + tendon cable

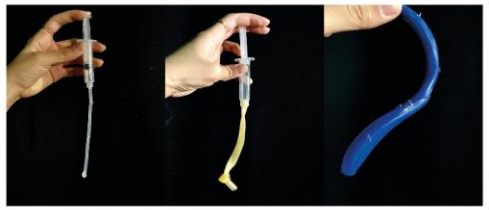
Same basic mechanism but with soft material. Gentle and more lively tactile sensation.

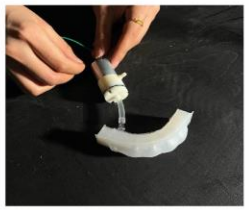
Inflatable Structures. Use different thinkness of the walls in different directions to make it bend.
Soft & flexible so easy to adjust to shapes and achieve gentle grasping movement.

soft mechanism (inflation)



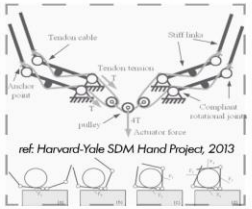
ref: Tentacle Robot by Harvard SEAS, 2022



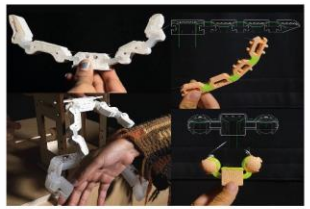


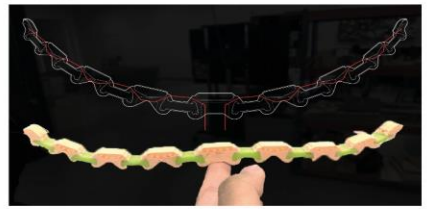
Ultimately, based on the criteria of controllability, stability, and flexibility, we opted for a mechanical structure composed of a combination of **stiff units** and **soft joints** and actuated through **tendon cable**,which is inspired by the Harvard-Yale SDM Hand Project (2013). We tried different shapes and aethetics to test their grasping performance and visual effect.

rigid + soft mechanism + tendon cable



ref: Harvard-Yale SDM Hand Project, 2013

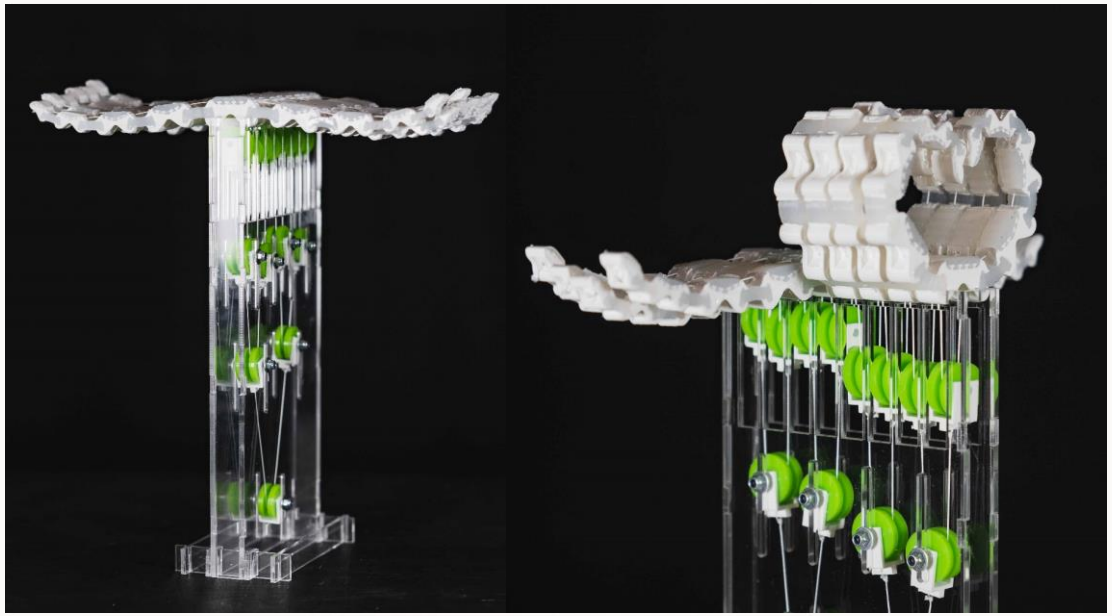


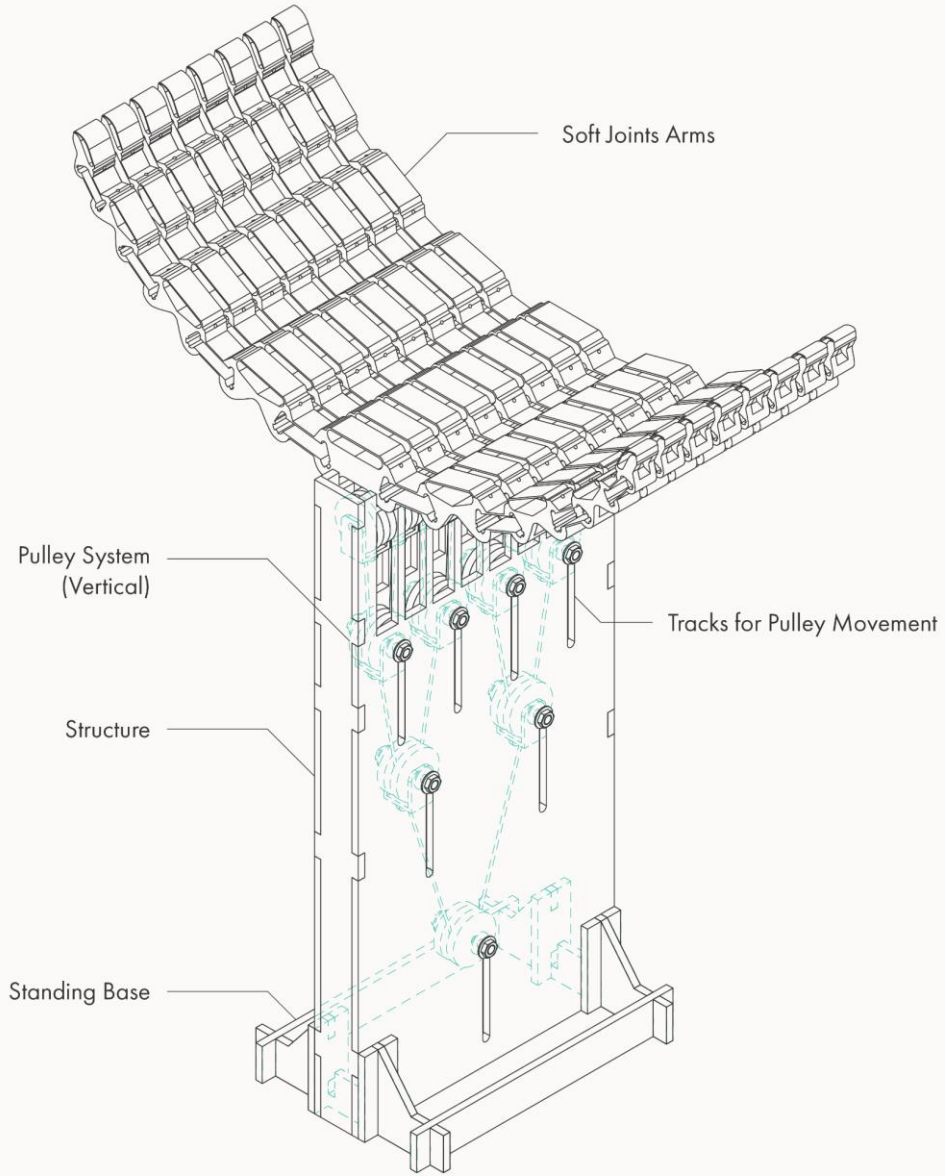


Prototype A-01

Building upon the SDM Hand mechanism, the final version of the Arms was developed.

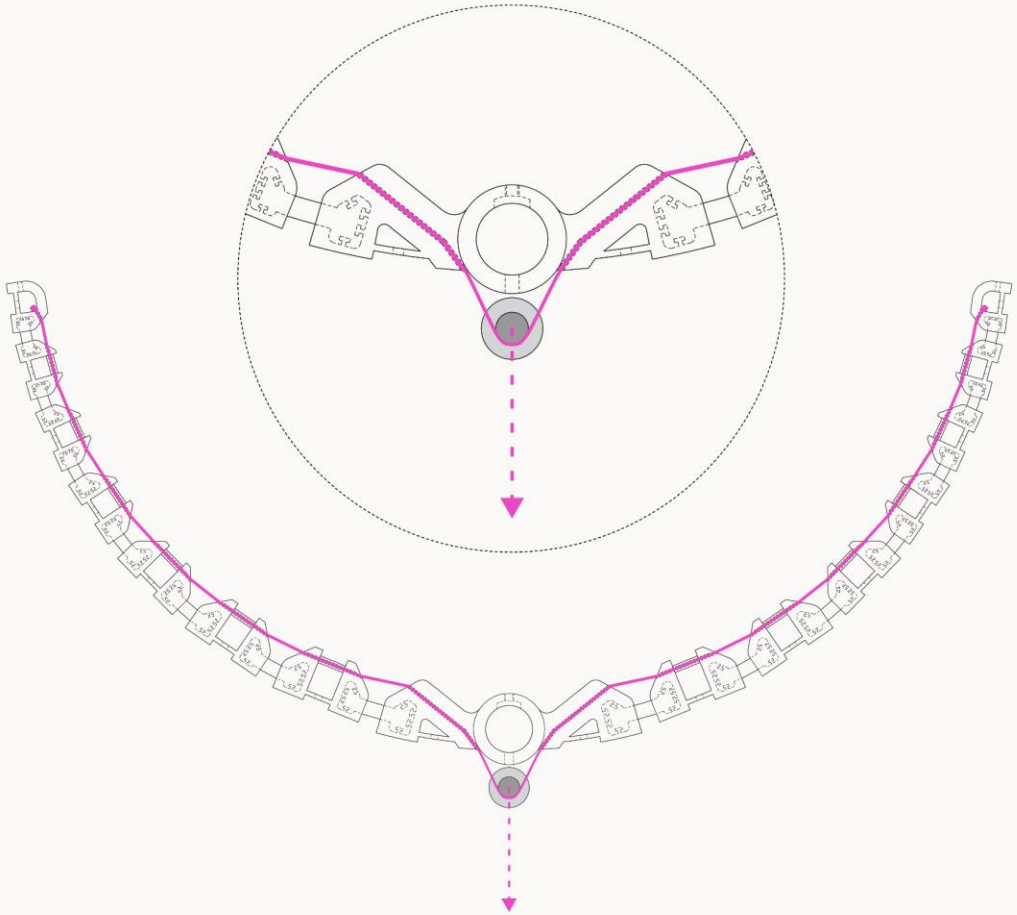
Prototype A-01 comprises eight sets of arms, with each arm consisting of fourteen 3D-printed rigid links and embedded viscoelastic joints made from urethane rubber. Eight pulling cables, as the actuators of the arms, converge into a pulley system that enables a single force to actuate all arms and all arms to flexibly adapt to various target shapes. This condenses what was once a complicated process involving digital sensing, heavy computing and multiple actuating into a single unified mechanism. In this way, the arms can move in a way that is unpredictable for software, making them more responsive to random inputs, which, in this interaction, pertains to the variations in object shapes.

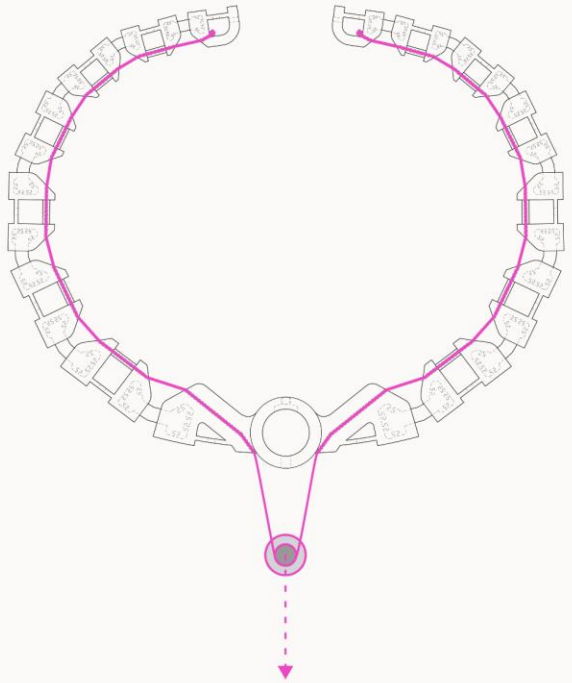




Human Scale: Correction

Based on the unsuccessful first human scale trial of the arm, we modified the design, made the units shorter and the joints thicker by harder elastomers, which is urethane with a Shore 60A hardness. This helped with the arm hold its weight.

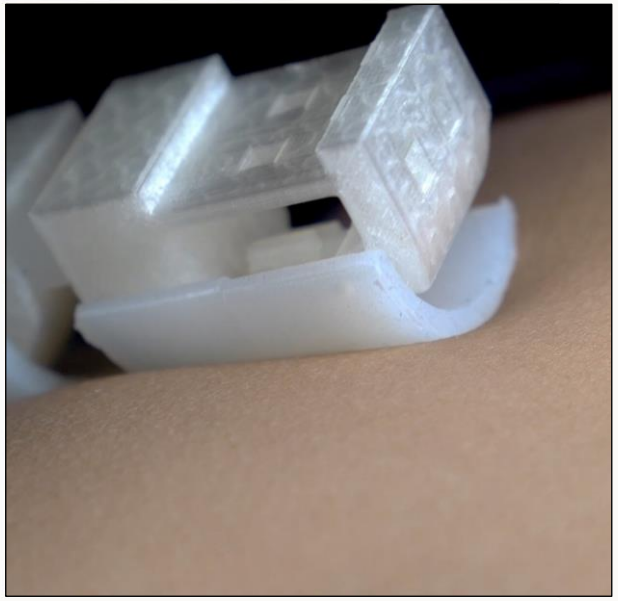


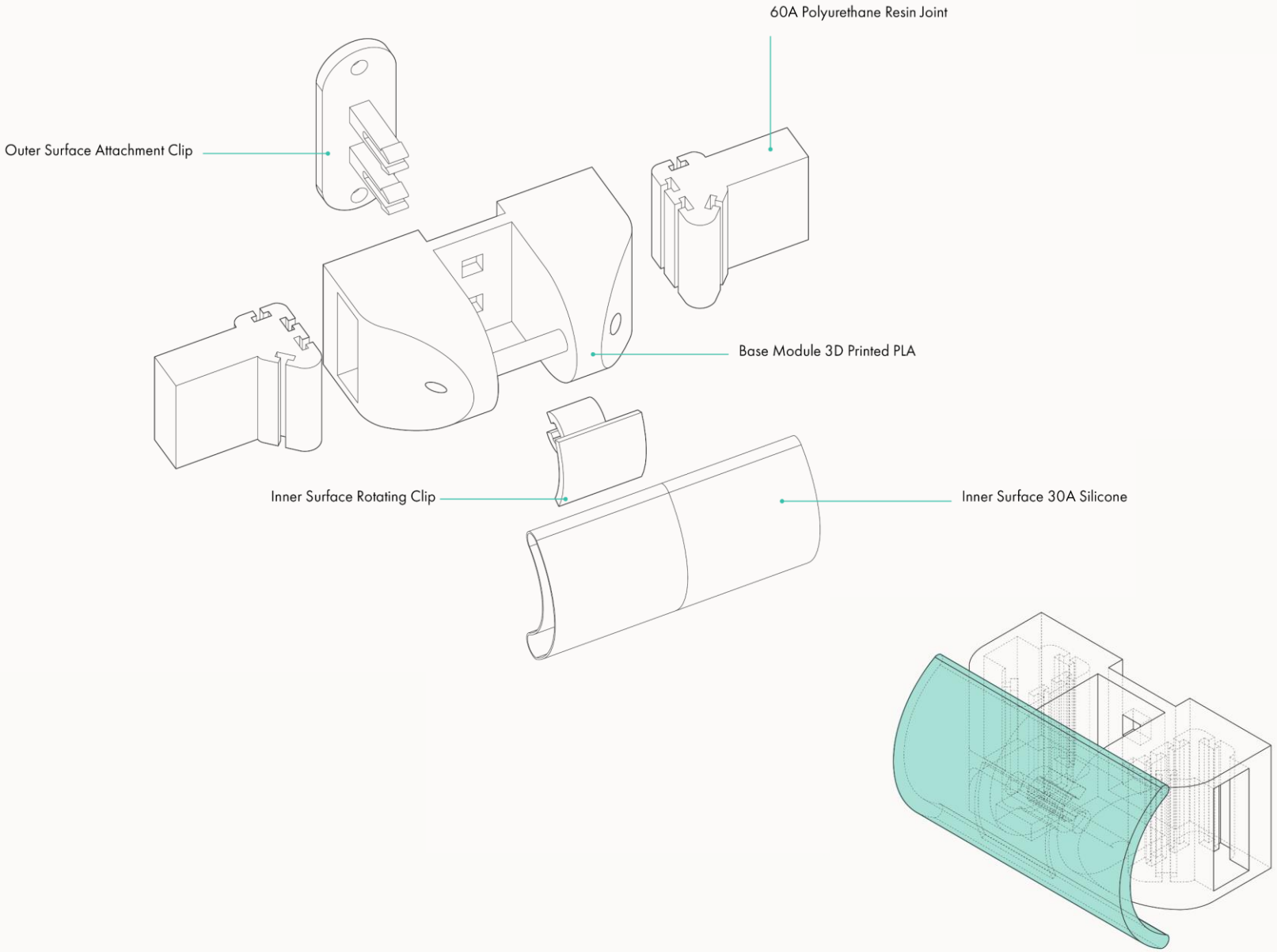


Inner Surface

In order to make the haptic experience welcoming and comfortable, the surface between user and machine need to be soft and adjustable.

An inner surface made of silicone is attached by rotatable snap clips. The rotatable clips makes the inner surfaces easily adjust to the user`s body and movement. Individually cast and clipped-on surfaces make it easier to make and modify especially for prototyping.

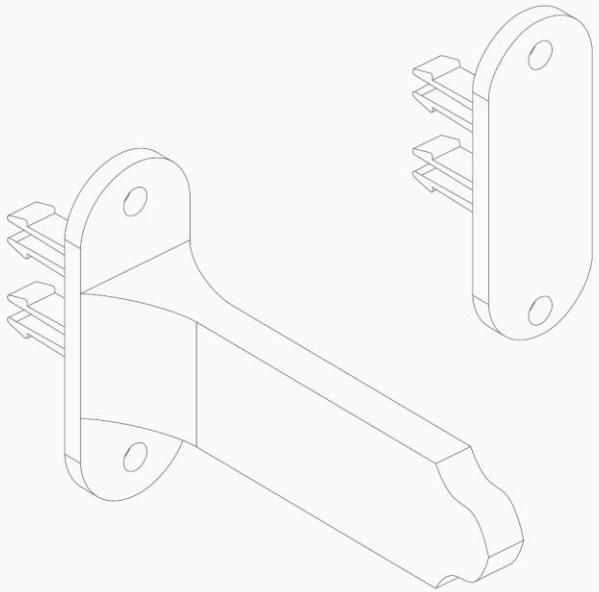




Outer Surface

To make production more efficient, we decided to attach material separately with the module using the clips.
Based on our concept, we wanted the machine to have a light and flowy aesthetic and hence experimented with paper and fabric.

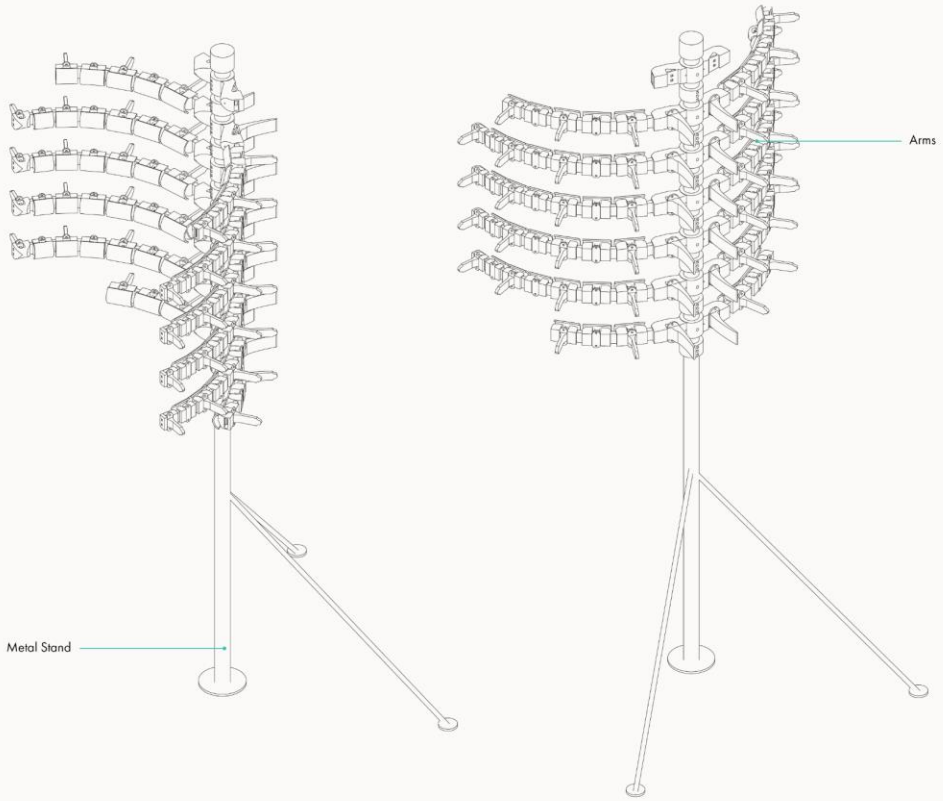
In the end we chose fabric as it gives a more enclosed feeling compared to small strips of paper.



Initial Project: Haptic Mirror

The arms were stacked on top of each other, and space slightly apart, to achieve a more emcompassing hug. The number of arms were decided based on how much of the human body we wanted to include.

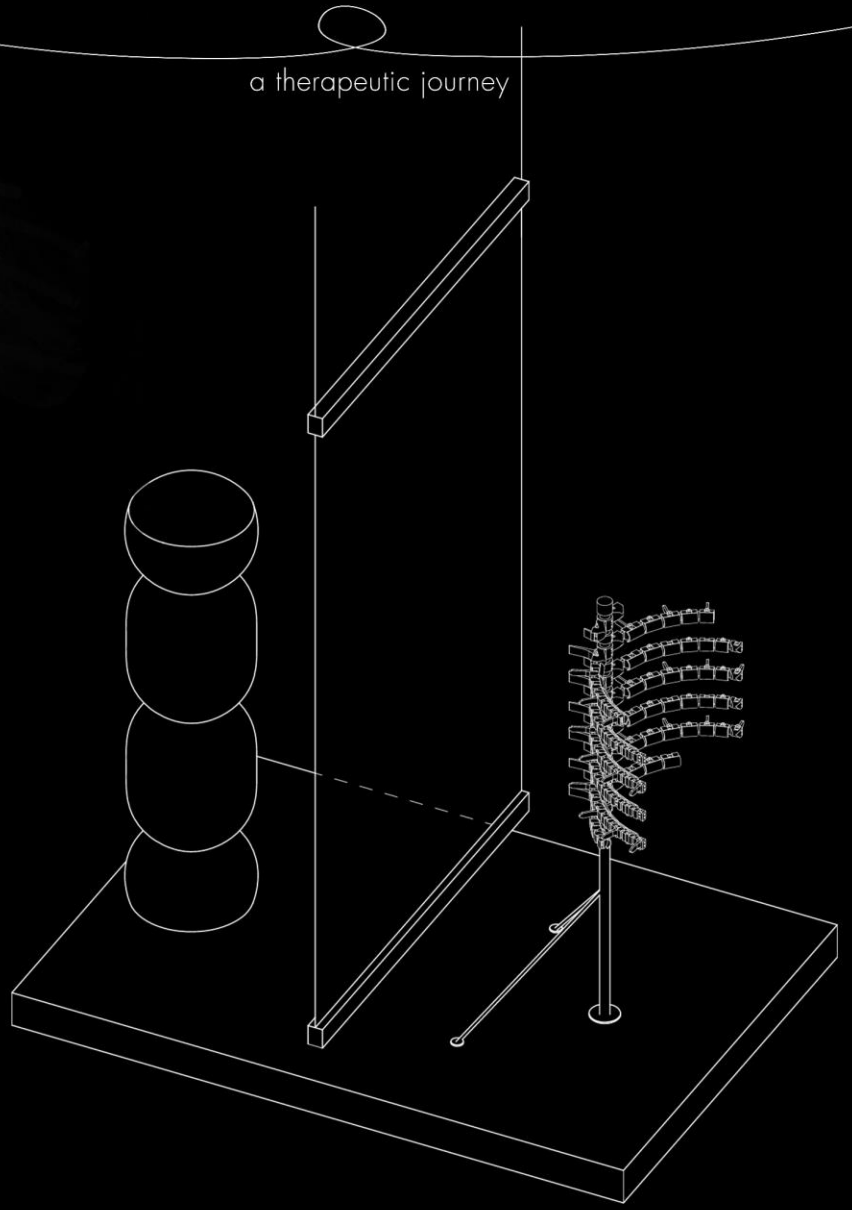
The stand was made of metal, to reduce the volume of the support, and yet be strong enough to hold the arms. This allows the attention to be solely on the arms.



Haptic Mirror

Records users' haptic interactions with the soft "puching bag" (by the embedded pressure sensor)

a therapeutic journey



Replay the previous haptic interactions through time and distance and transform them as different type of hugs. (with different number of arms, different strength and different duration)

More Project Details on: https://www.bingluu.com/hapticmirror

Orientation

Two structural configurations, namely, an Upright position and a Laydown position, were developed during the design process to investigate different approaches to human-machine interactions.

In the Upright design, the main structure stands vertically, with the arms operating parallel to the ground (Diagram 1). In the Laydown design, the arms extend vertically upwards from a bed-like structure where the user can lie (Diagram 2). The Upright orientation took form from how embrace is typically performed in real life.

Similarly, Petri Eskelinen's Mechanics of Hugging (2014) portrays hugging this way in his design. This structural orientation allows users to decide when and how they approach or move away from the machine. For instance, they may walk up with their back facing the machine for a back hug, maintain a distance for a bridge hug, or reduce the gap for a more intimate hug.

The Flat orientation drew inspiration from Lucy Mcrae's Compression Carpet, where the user relinquishes their freedom of movement, ceding control to the machine or its operator. This structural orientation establishes more distinguished divisions between the user and other spectators, making the interaction between the primary user and the machine feels more direct. The experience also feels more formal, as the user must prepare to enter and exit the space, contrasting with the more casual encounter depicted by the Upright interaction.

Diagram 1

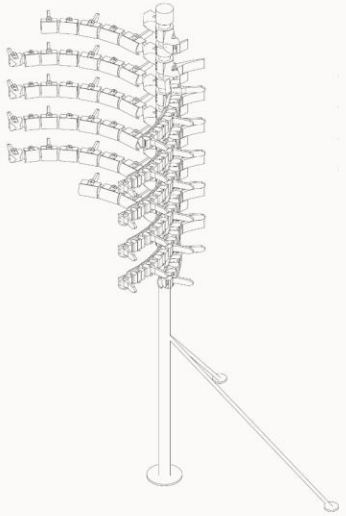
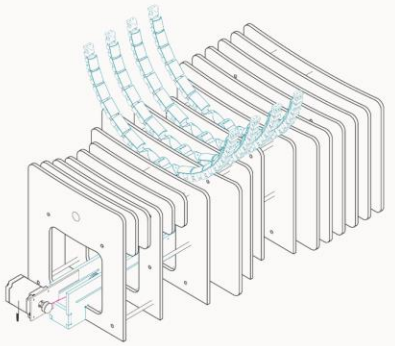


Diagram 2



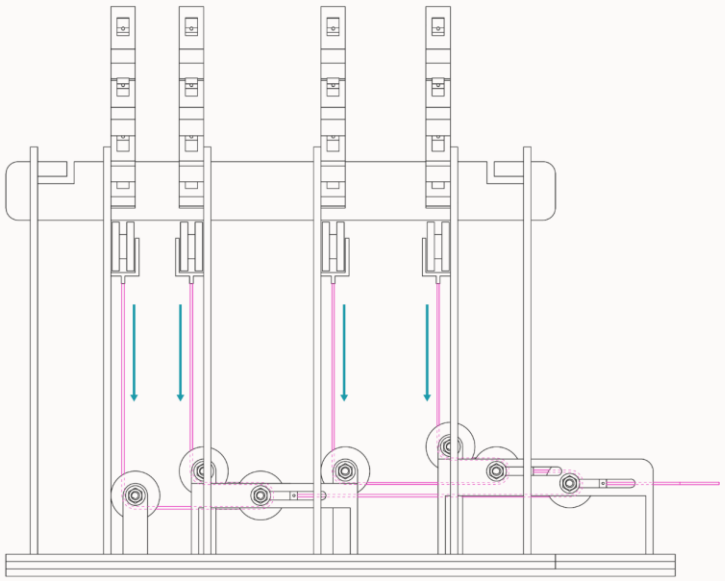
Petri Eskelinen's Mechanics of Hugging (2014)

REF

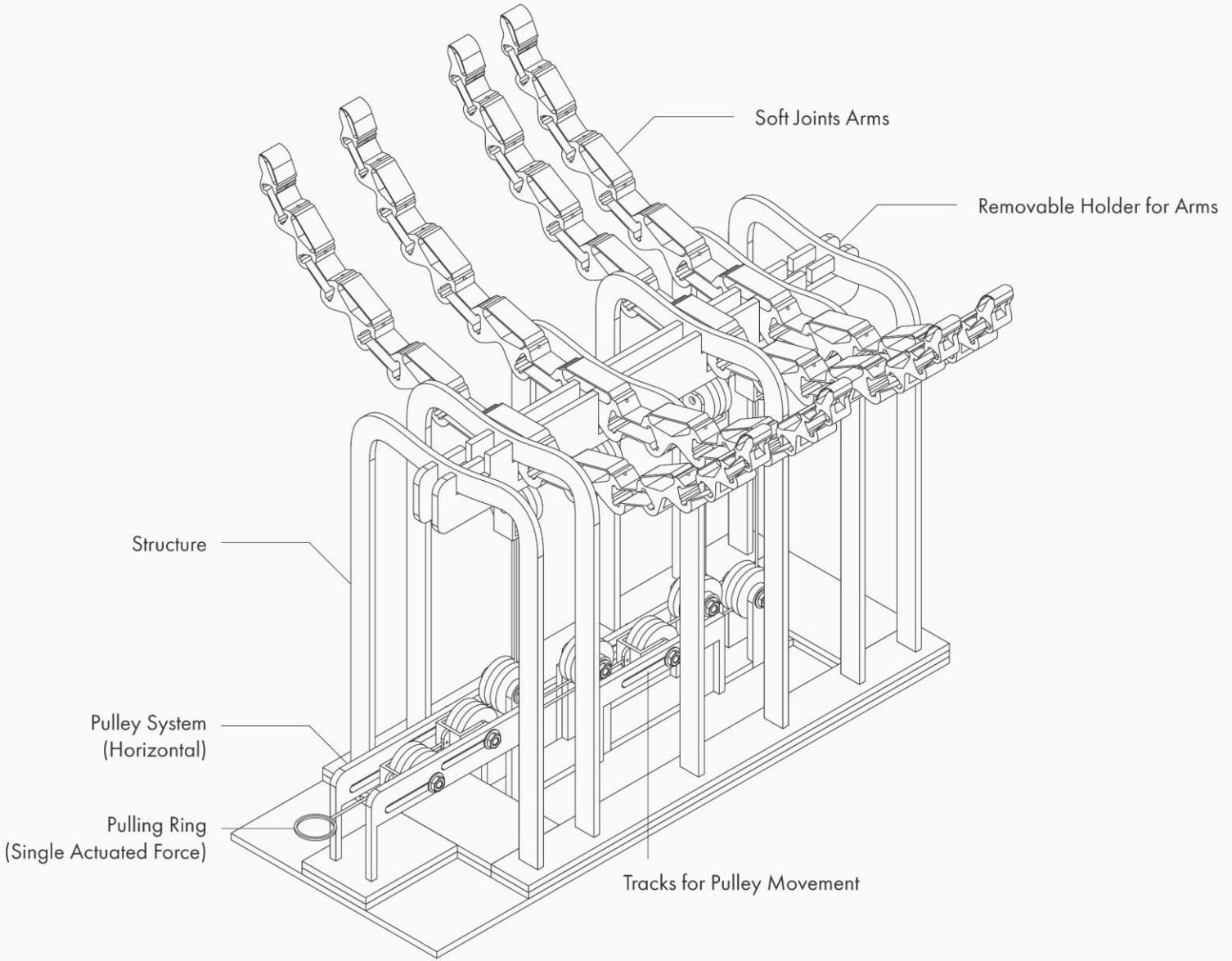
Lucy Mcrae's Compression Carpet

Prototype B-01

The pulley system had to be redesigned in order to achieve the laydown position, as the previous version occupied a lot of space vertically. This would in turn make the height of the bed very high. Hence, pulleys were utilized to change the direction of forced and reduce space used below the arms. We also reduced the number of arms to 4, and tried to place them at varying distances so they could hug different parts of the body, while avoiding intimate areas.



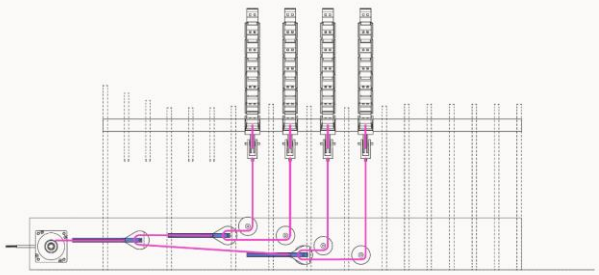
Side Elevation and Pulley System

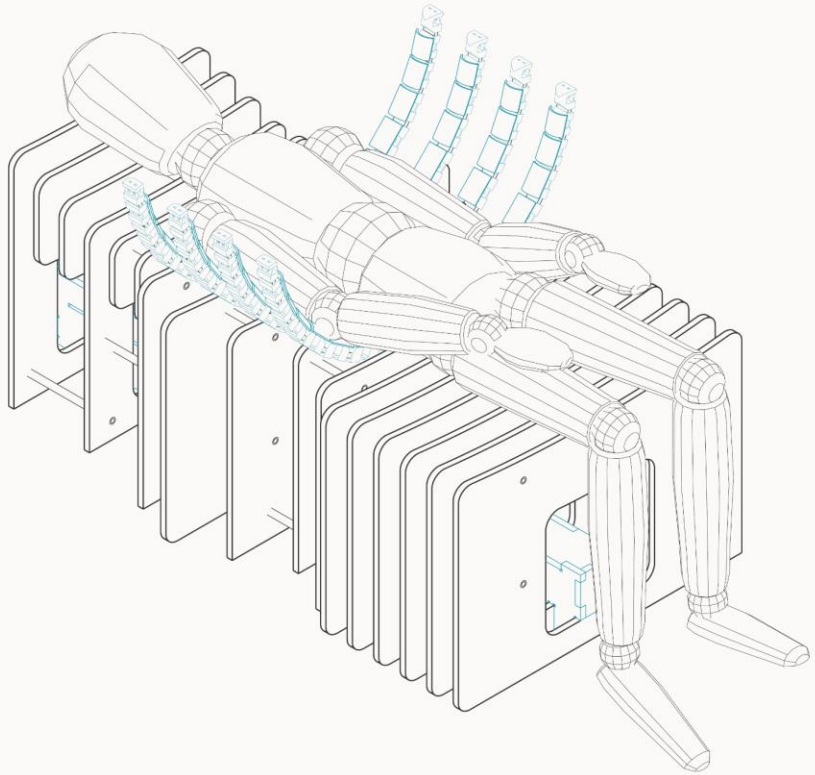


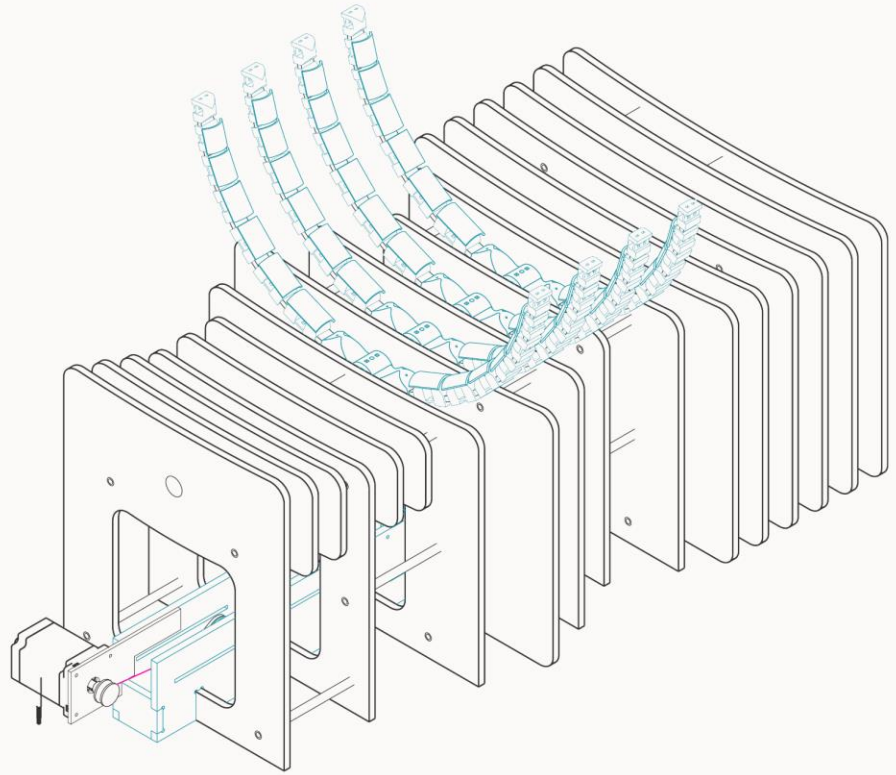
The Hugging Bed

In the end we maintained equal distance between the arms since it is hard to adapt the distance based on which body part the arm hugs as it would vary from person to person. This orientation of the bed allowed the arms to perform a wider range of motion in comparison to the standing version. This allowed for a more visceral response from the user and audience alike.

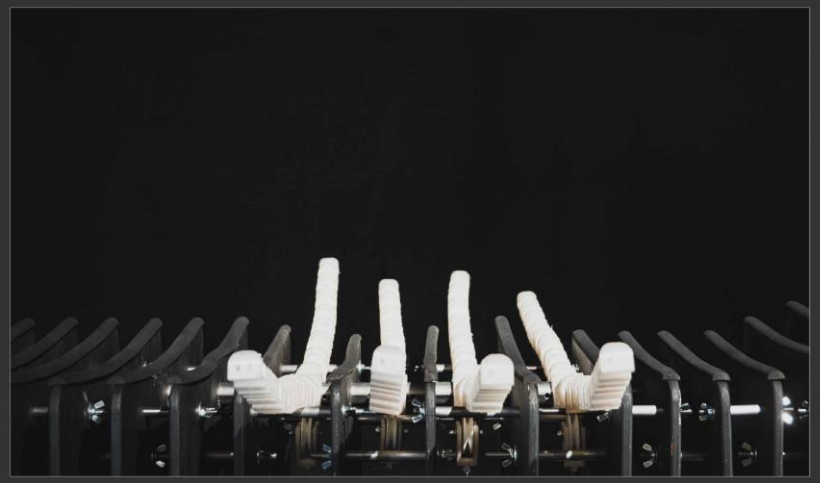
The support structure for the human scale bed was made with 12mm plywood arranged in slats, which allow openings for the arms to be placed in between while also making space for the string and pulley system to co-exist with the structure. The wooden slats slightly rise at one end, to create a headrest, subtly indicating the how to use this bed.





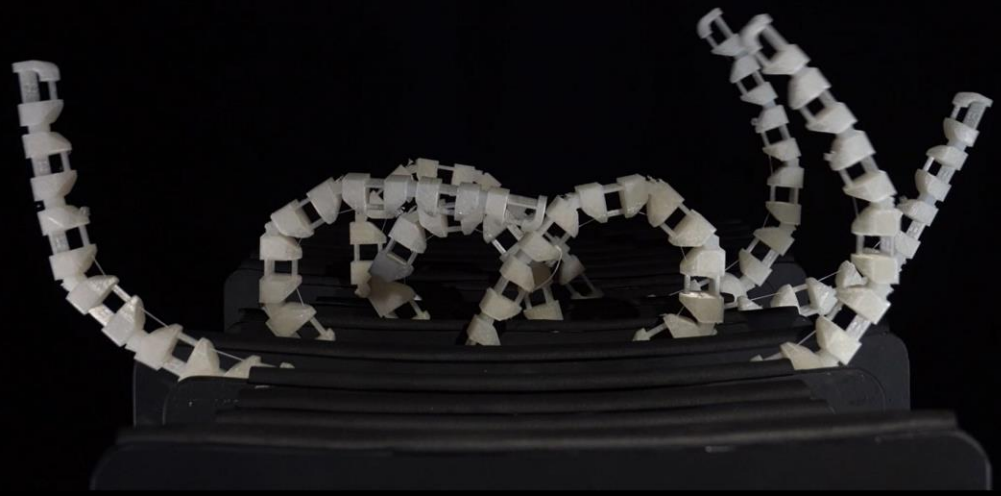


The Hugging Bed



Hugging Bed

- Can the nuances of human touch be replicated by a non-human entity?
- And can we build connection between human and machine through touch?



- Within tactile interactions, non-human entities might transcend materiality, developing their own tactile language that parallels and complements the nuances of human touch, and builds human-robot trust through touch.

Full video on: https://vimeo.com/906025783
More Project Details on: https://www.bingluu.com/huggingbed

London Festival of Architecture

We exhibited the bed for the first time at the London Festival of Architecture. While the people were on the bed, or after, we asked them some questions that would help us in our study. Some of the questions we were:

1. How does it feel to be hugged by a machine?

2. How does this sensation differ from receiving a "real" hug from another human being?

3. Did the experience turn out to be different from how you had imagined it at the beginning just by looking at the device? In other words, did the visual aesthetic influence your anticipation of the experience?

4. Do you think the experience would be different knowing that the machine is completely automated as opposed to being operated by a human?

Exhibition documentary on: https://vimeo.com/913562538

London Festival of Architecture

Several participants conveyed the desire to reciprocate the embrace extended by the machine, this longing to return the hug can be interpreted as a manifestation of the empathic bond the participants formed with the machine, underscoring their desire to sustain the dialogue with it.

Others wished for the hug to be tighter or warmer, while some were pleasantly surprised by the gentleness despite the visuals. Some felt more comfortable knowing a human is controlling.

Tragic Tale of Identity

The reaction at LFA was varied. Some were positive and showed wonder or fascination while others displayed more negative reactions such as fear or rejection. Based of its embracing movement, people kept calling this the hugging machine, essentially leading it to become the imposed identity of this machine. It was perceived to hug anyone, a repetitive action, and made us consider the performative aspect of identity and how it can be used to subvert imposed norms.

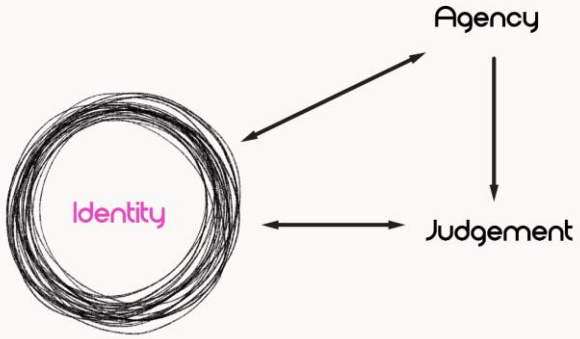
Not just a hugging machine!

About Judgement

The idea of judgement plays an important role in our experience, and it exists on two levels. At the beginning, the people judge the machine based on its atypical visual. Much like how the people around us judge us and how we can perceive this in their expressions or movements.

We wanted to explore what it would be like if our machine had agency. Instead of hugging everyone, what if it could choose who to embrace? This is the second level of judgement.

In the case of a machine, there is an overlap in the rigid framework aspect of identity with the set of rules that human designers establish, setting boundaries to agency.



"Identity is the repeated stylisation of the body, a set of repeated acts within a rigid framework..."

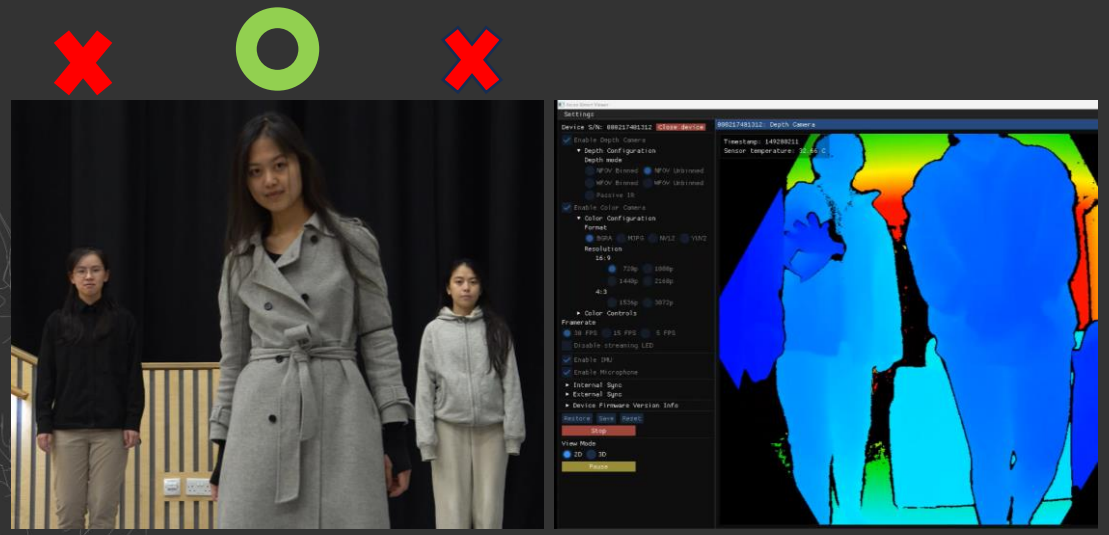
"It is only by changing and manipulating the repetition of those acts that a subversion of identity becomes possible"

(Judith Butler, Gender Trouble, 1990)

What if we give it agency so it can judge?

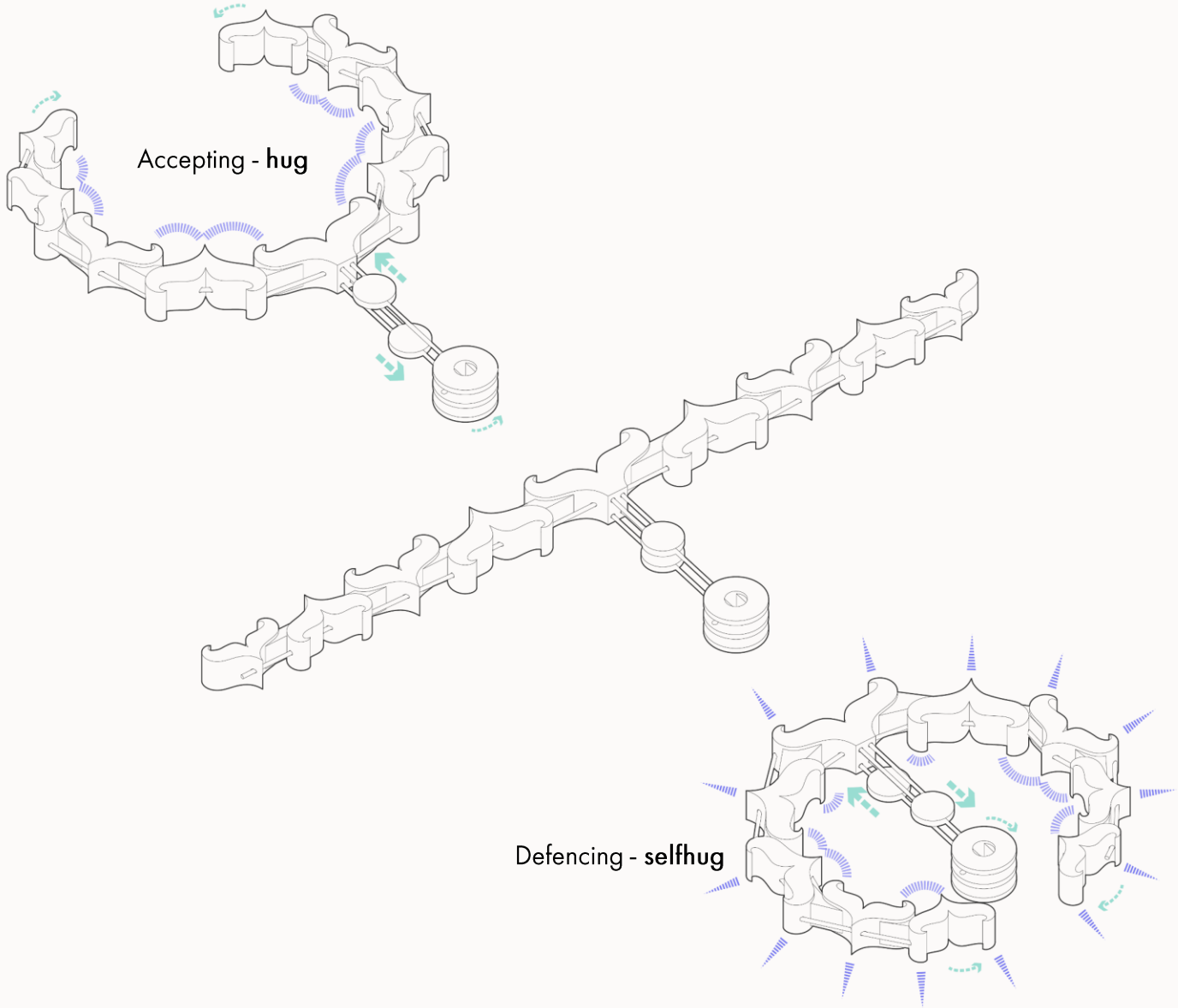
While machines cannot exhibit true direct personal agency, due to factors such as intentionality, they can exhibit agency in different ways. For example, it is useful to refer to machine agency in terms of the intentions of their human designers, as interactive technologies may be deployed to change human attitudes or behaviours (Fogg, 1998).

Here are two machine judgement examples: Visual Analysis vs. Depth Camera

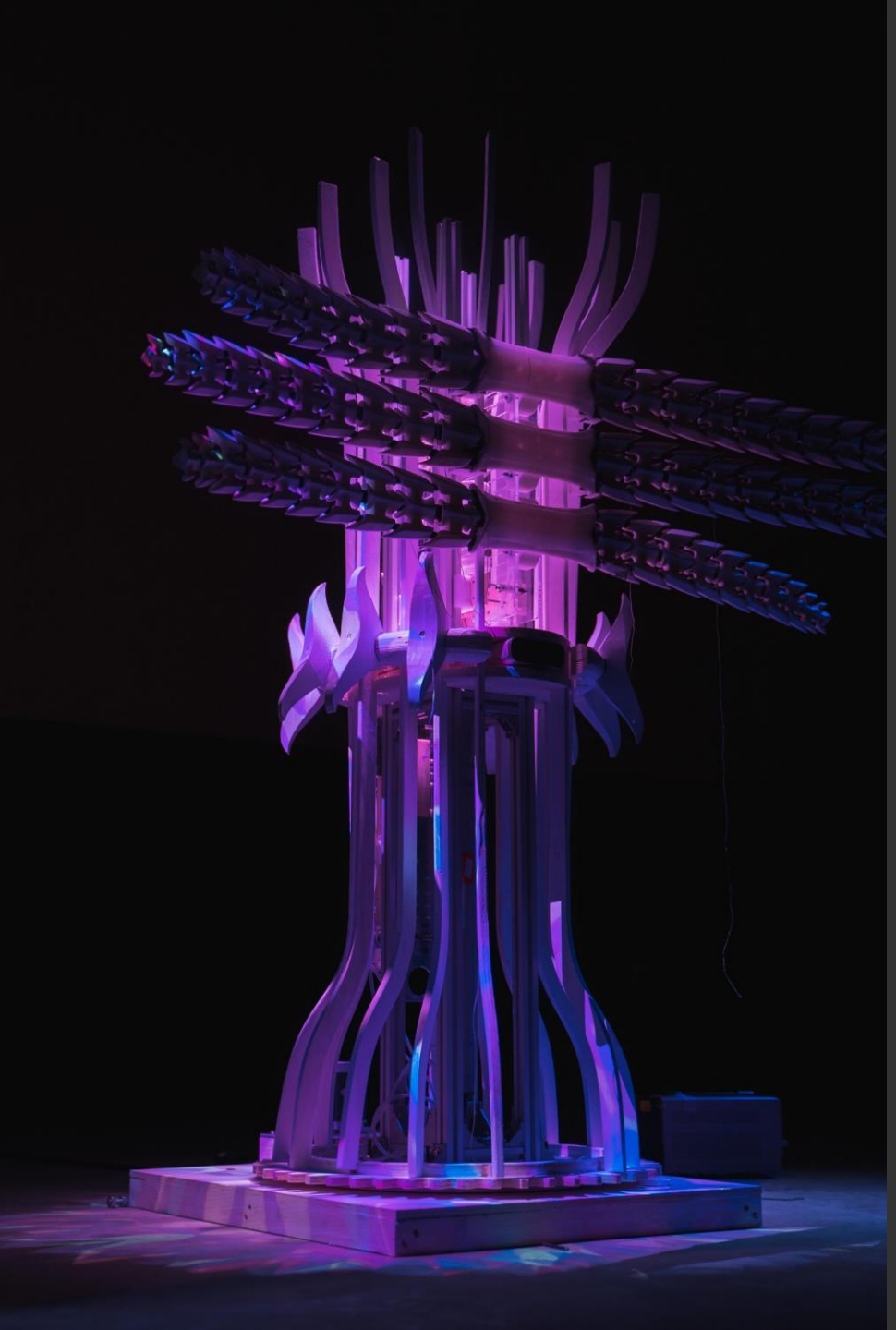


Machine Judgement: Movement Output

Using semiotics, we aimed to achieve a visual contrast between what people see and what they feel. The sharp, pointed edges indicate attack and self protection, while the curves symbolize acceptance.



Prototypes showcased in Ars Electronica 2023, Linz

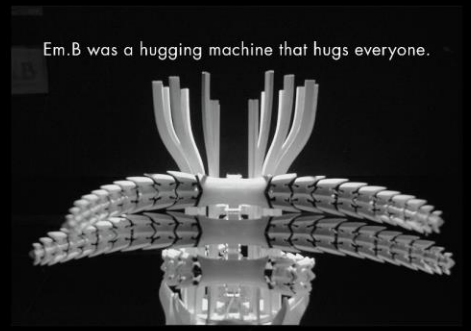


Introducing Em B.

Em.B is a kinetic installation that invites participants to explore the concept of machine agency and the capacity for humans to establish empathic connections with non-human entities. The work attempts to transcend the mechanical nature of these entities, enabling them to cultivate their own tactile language that conveys gestures of comfort reminiscent of human embraces.

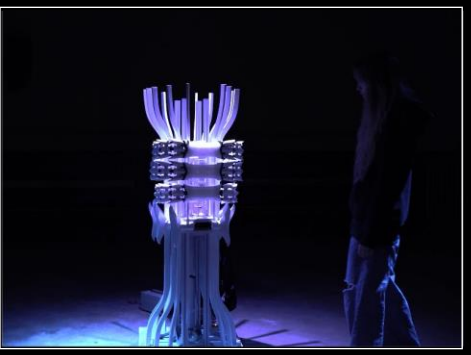
At its core, the project unveils the intricate interplay between an individual's identity and the surrounding world. The machine defies people's preconceived expectations by acting in ways contrary to its character, making the decision of who will receive its embrace. Judging from the observer's movement and physical responses to its atypical visual aesthetics, the machine determines whether to extend a physical embrace to the chosen human or remain in a self-hug as a form of protection.

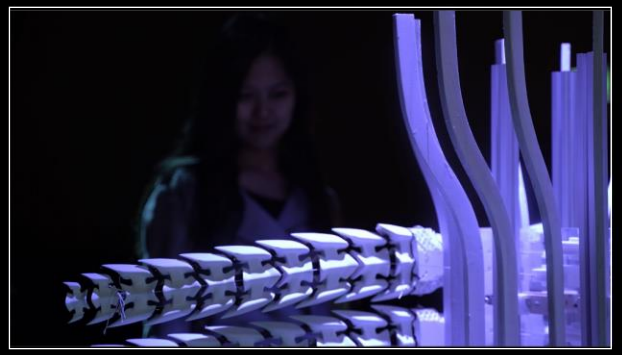
The design uses digital sensing, motor-actuated pulley systems, and soft robotics to mimic human-like behaviours. These systems combine to form a heterogenous assemblage whose aim is to reignite our connection to bodily sensations and act as a conduit for kinaesthetic dialogue.

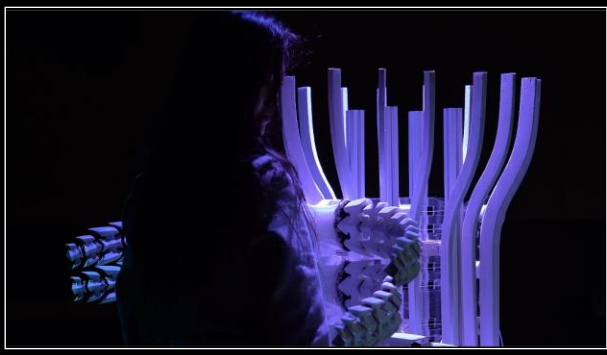


Em B.

Full video on: https://vimeo.com/904510504
More Project Details on: https://www.bingluu.com/em-b





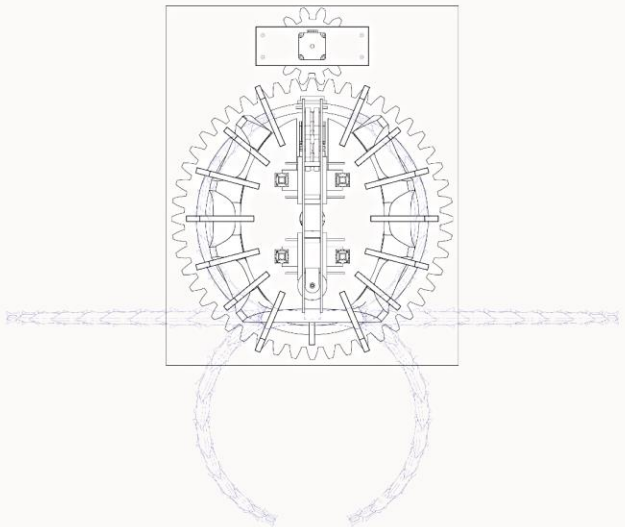


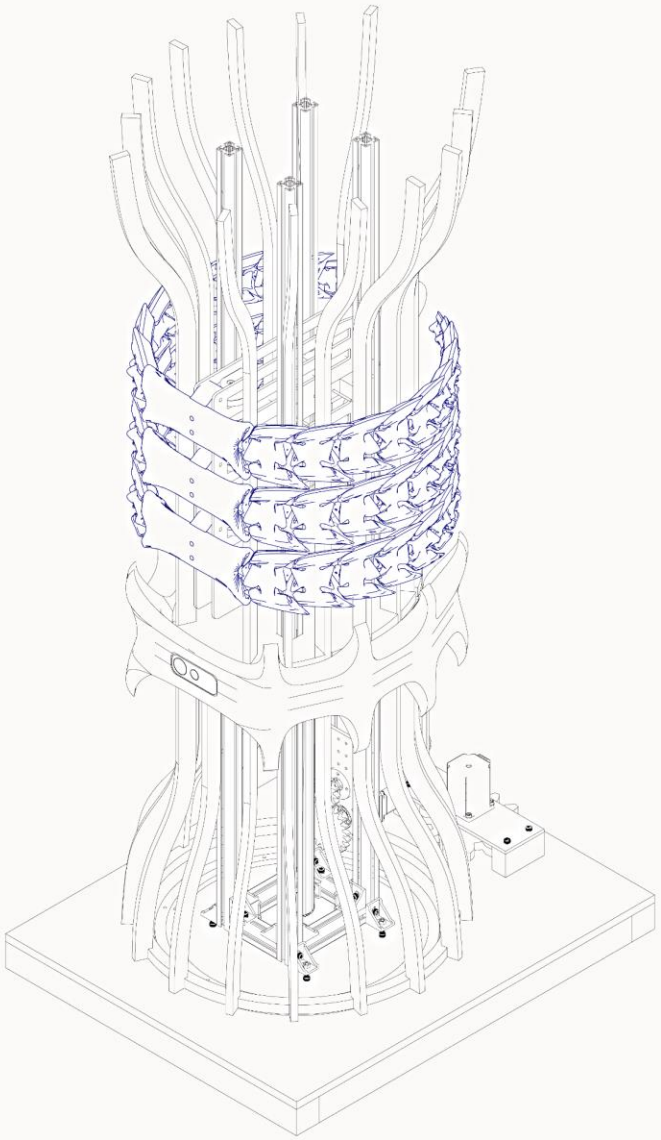
Em.B now has its own agency.

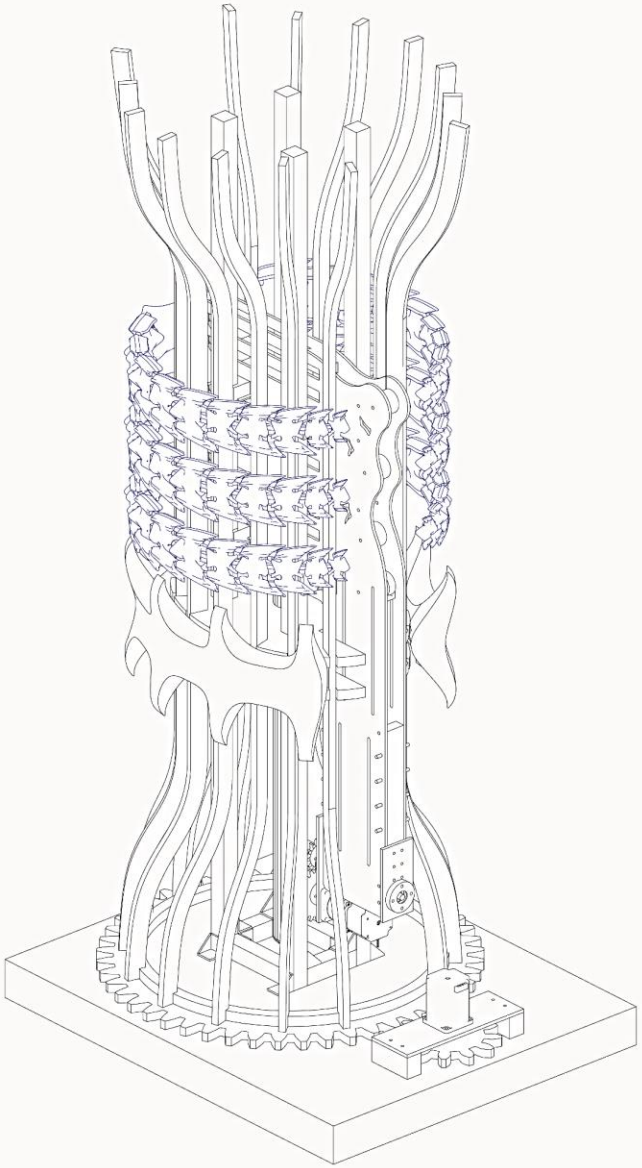
It begins by scanning its surroundings, observing and analysing the audience's behaviour and expressions in response to itself, as well as their distance and movement tendencies. It then selects only friendly audience members for further interaction.

It opens its arms as a sign of acceptance. The depth camera then detects whether the chosen person is moving closer.

If the person approaches, it adjusts its height accordingly and finally gives a full hug.

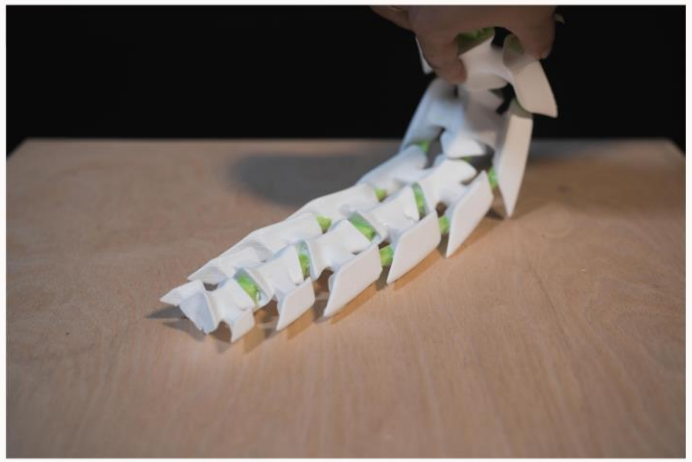


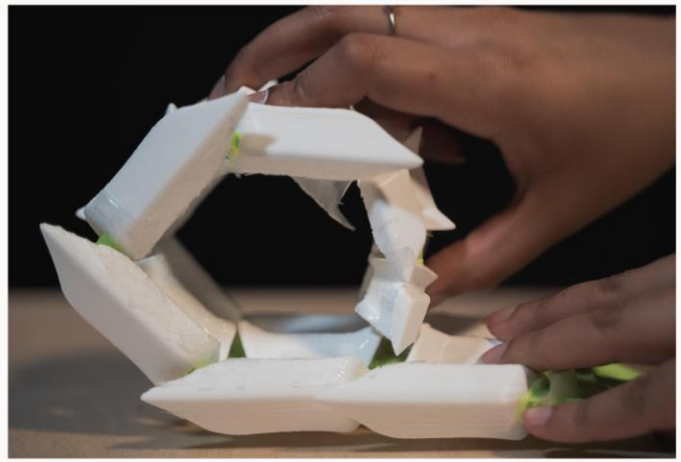




Final Arm Design

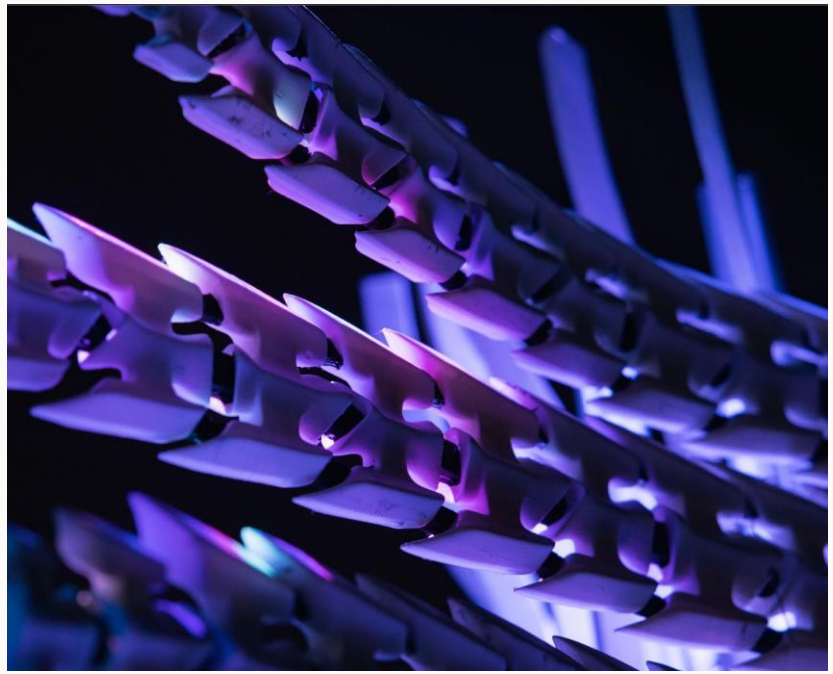
To prevent the arms from dropping down, we decided to develop a two-layer or multiple-layer of the arms instead of the single-layer version. Also, to achieve the protecting / defending movement, we followed the same design logic with the Ars Electronica Arms.

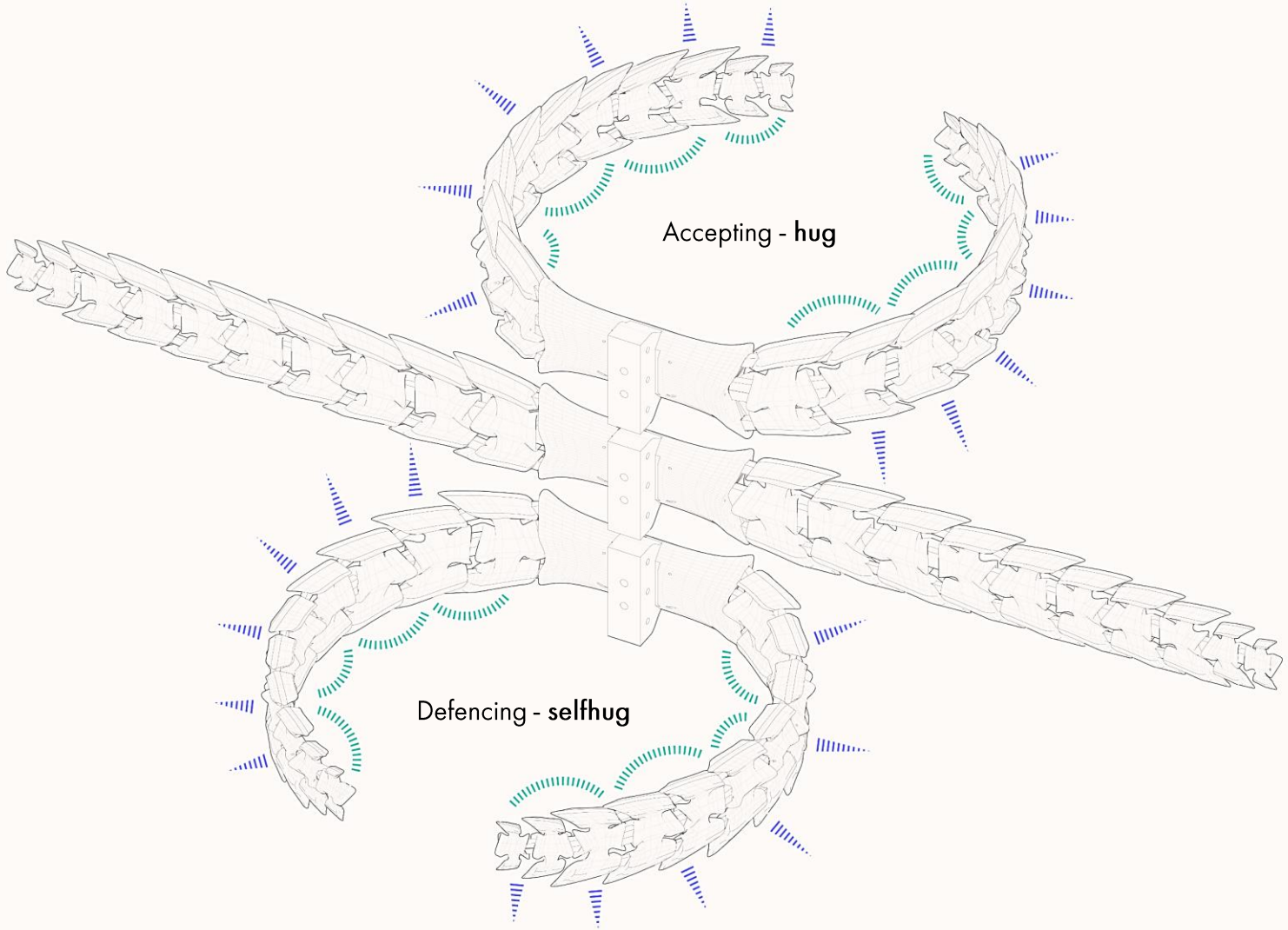




Final Arm Design

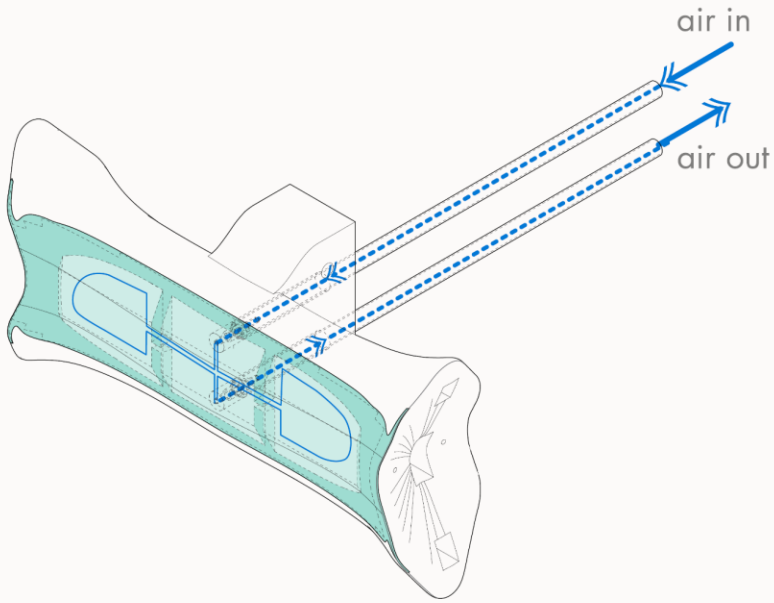
Forms that have sharp-shape edges which look spiky and aggressive, but will hide in neighbour units and become curvy and protective when it is giving hugs. We tried with different aesthetics and finally combined them into a 3-layer stable and organic-shape unit.

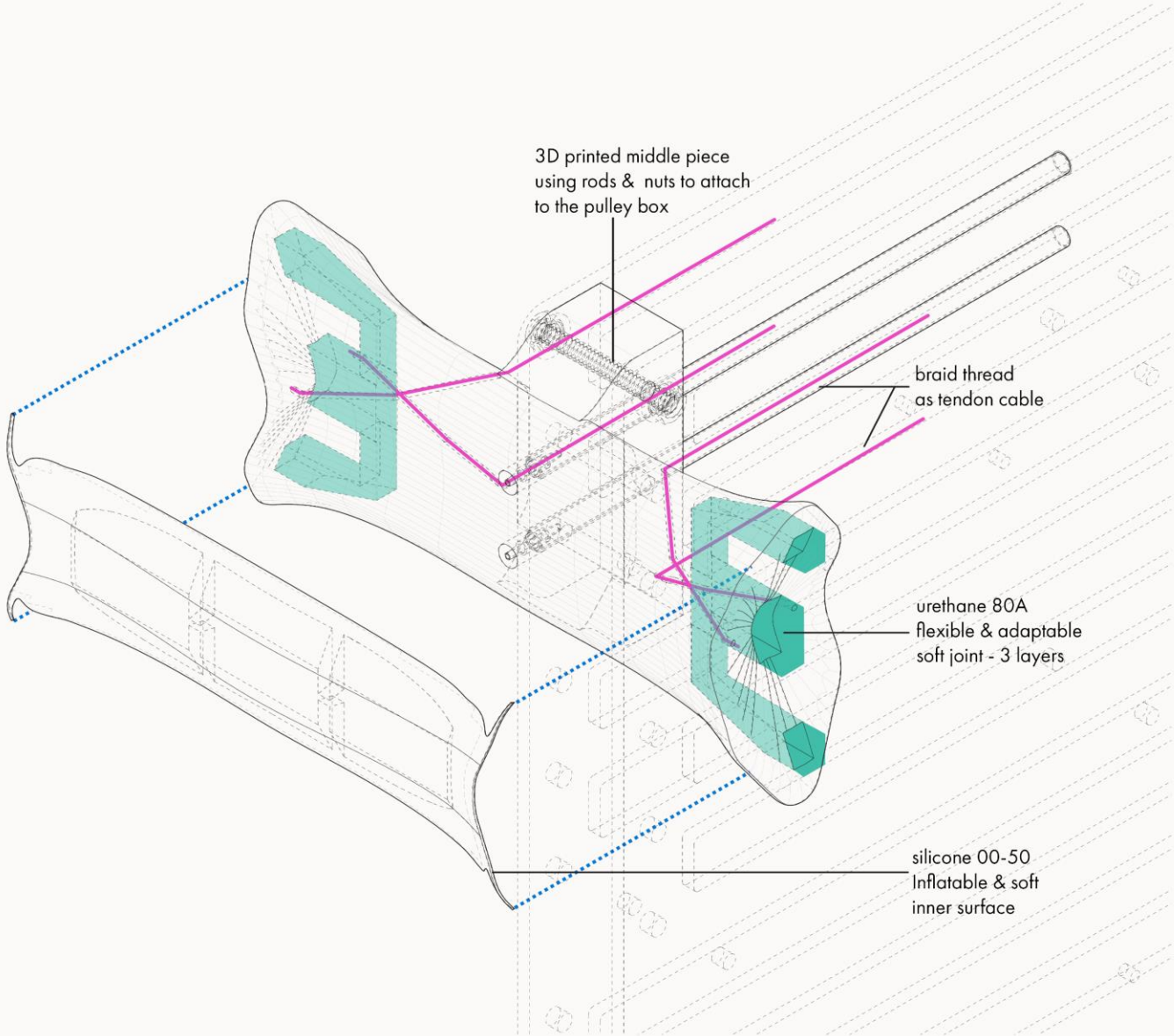




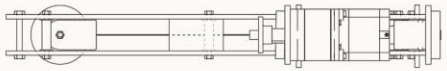
Breathing Mechanism

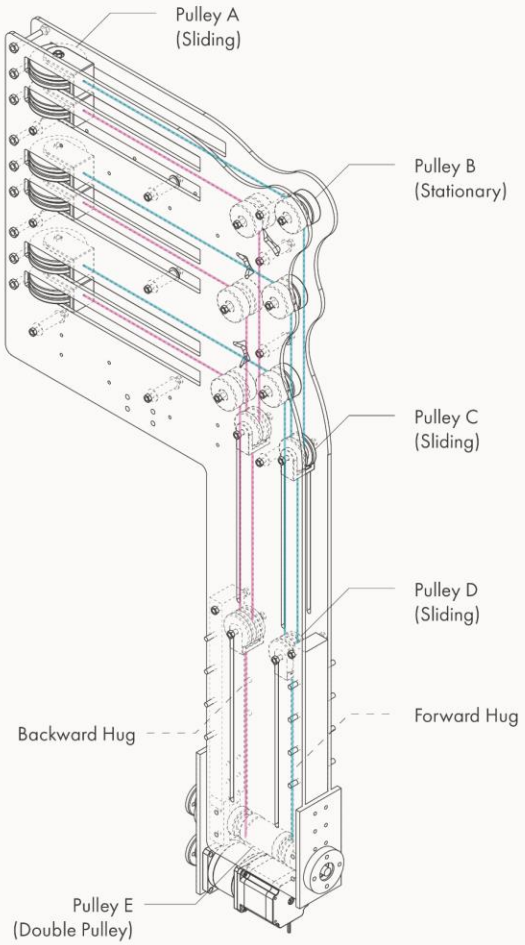
The soft surface for the final project has been developed from attached soft surface clips to brushed-on silicone, which will provide an easier and more efficient way for the complicated form of new units. For the huge middle piece, we would like to make great use of the property of silicone and add additional human-like movement to make the whole experience more varied. with the inflation and deflation of the designed silicone structure, it can reflect the breathing movement of living entities. Besides, when people get hug from the machine, they will also feel the breathe and pressing through bodily contact with the middle piece.

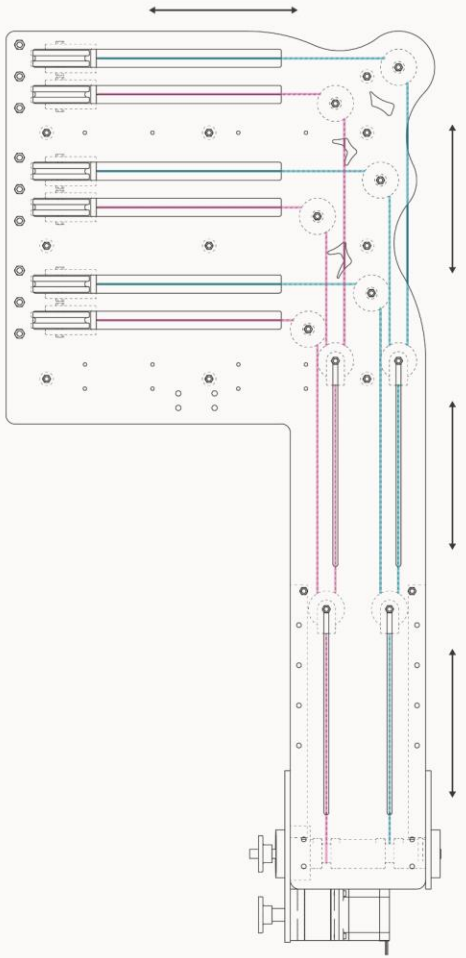


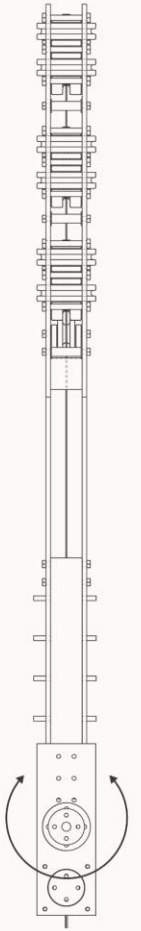


Pulley Box: Inside (Diagram)



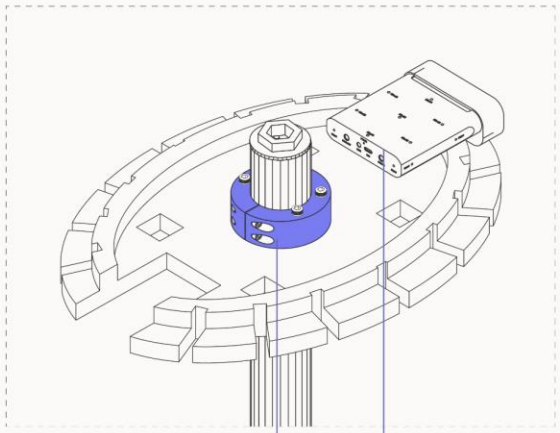


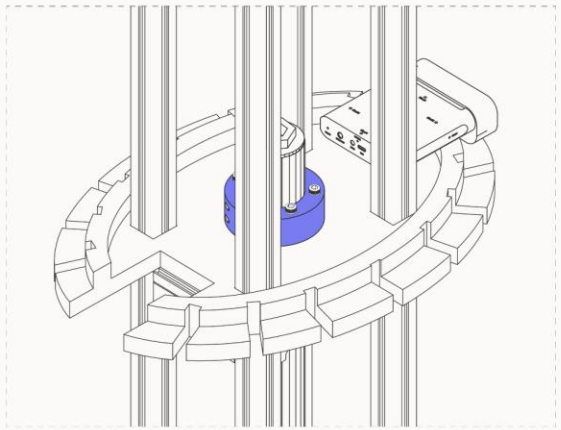




Core Structure: Vertical Movement

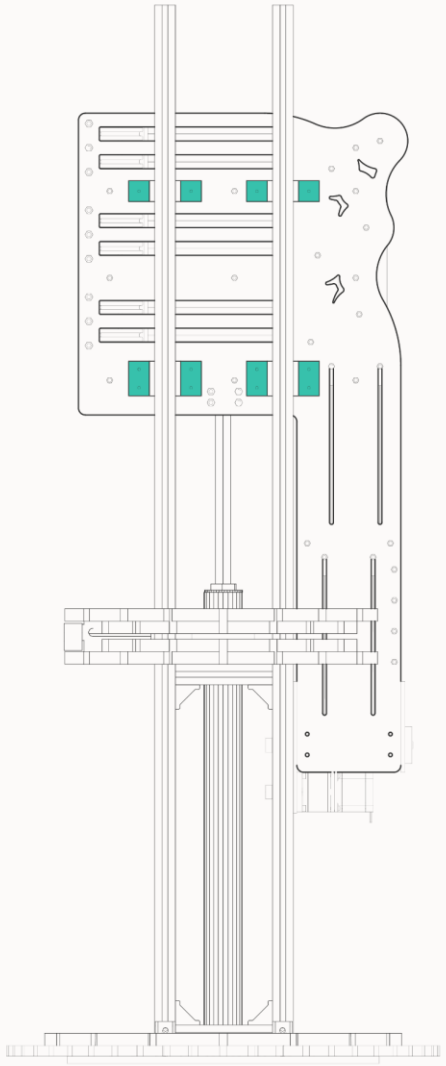
The vertical structural core is made up of 4 30 x 30 mm aluminium profiles held together by smaller sections of aluminium profiles at two levels, creating a strong base for the mechanisms nested within and on it. The linear actuator sits on top of an18mm plywood base, which is supported by aluminium cross sections. The actuator is held in place by a custom made aluminium bracket. The kinect used for motion and depth tracking also sits within this ellipse. This base also contains slots for the fins to sit in.

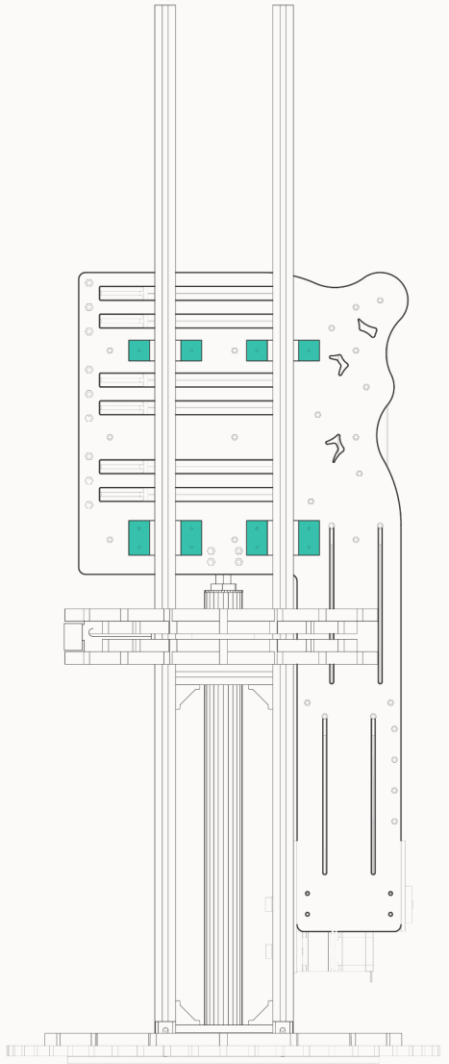




Custom Aluminium Bracket for Linear Actuator

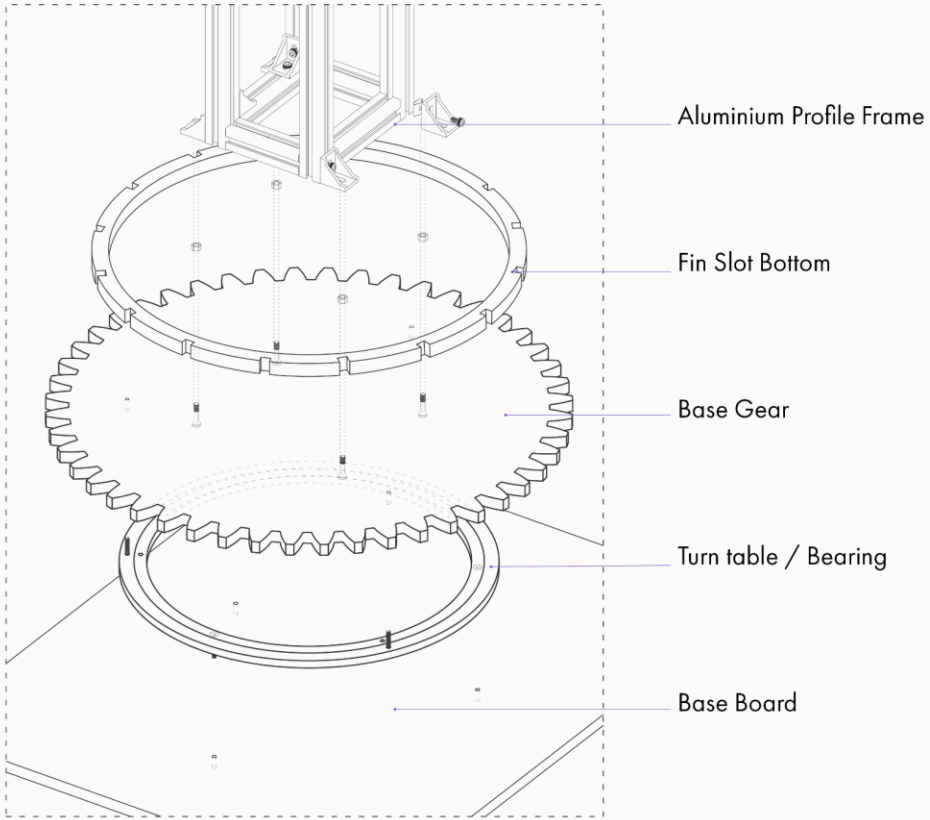
Kinect Azure

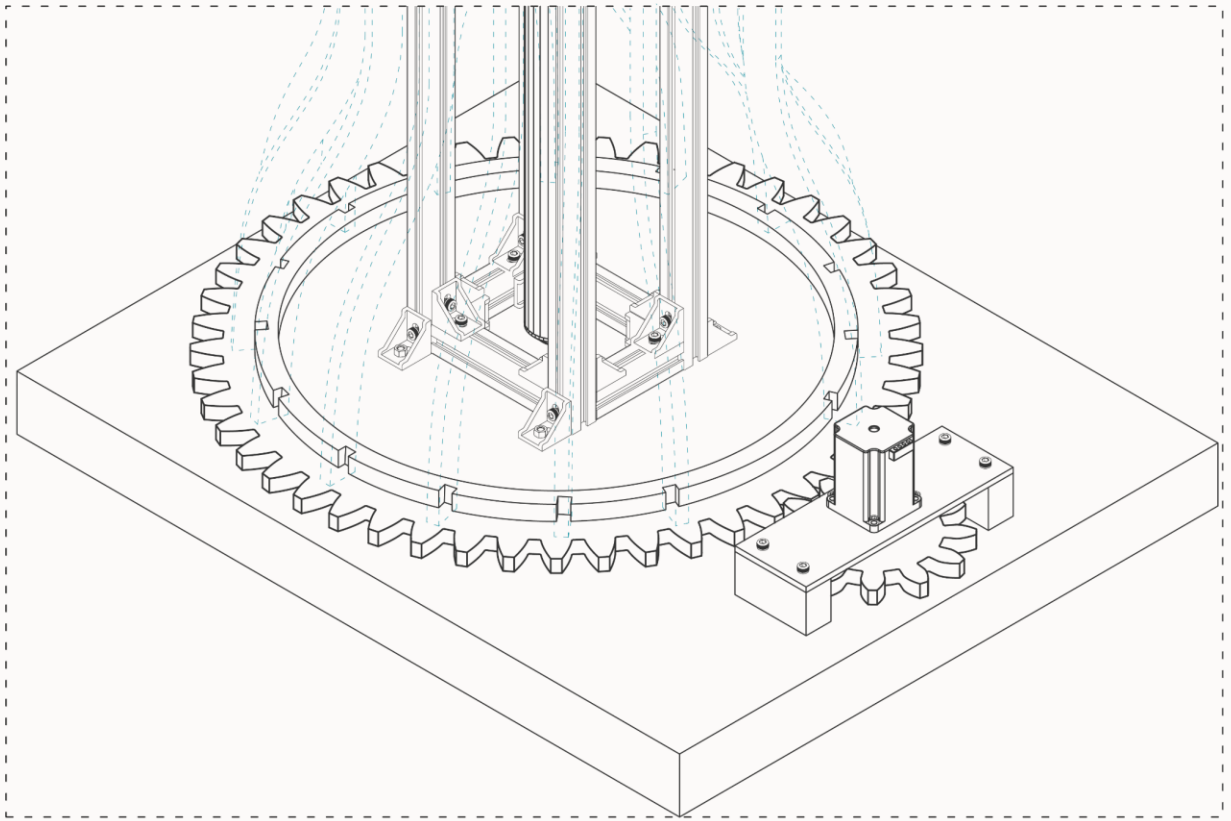




Machine Movement: Rotation

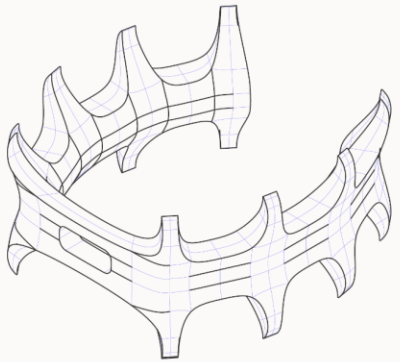
The rotation is achieved with a gear mechanism on the base board. The structure rests on the larger gear which is attached to the base with a large bearing or turntable. The aluminium profile is attached to the gear for safety.



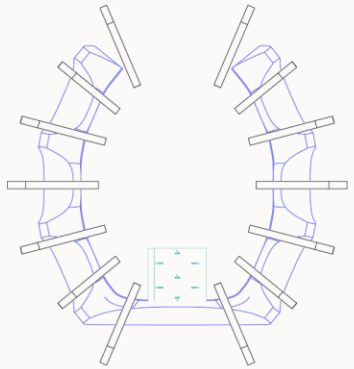


Exo Skeleton

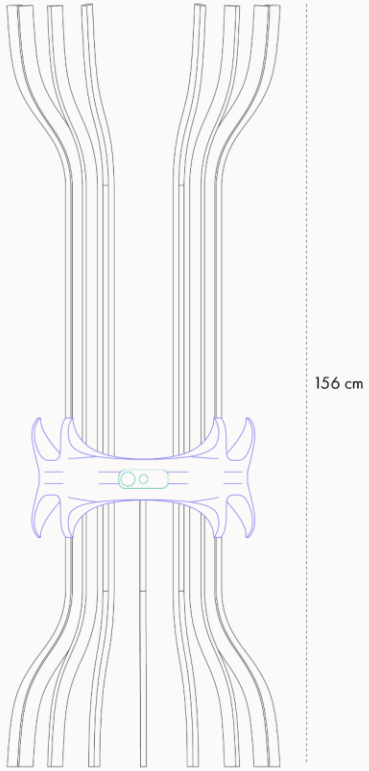
The final design is more elliptical in shape, to accomodate the pulley box, however this also helps orient our structure. The fins are made out of 12mm Birch Plywood, which was CNC milled. The belt in the middle is to house the kinect but also hold the vertical fins in place. The 14 fins give a glimpse of the internal mechanism while also concealing it from certain angles.



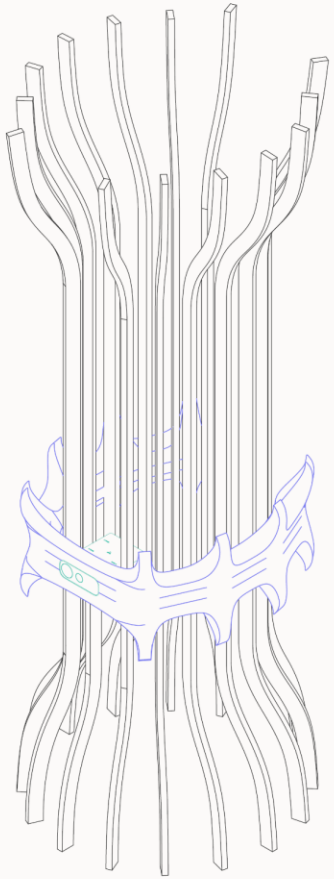
Kinect Belt



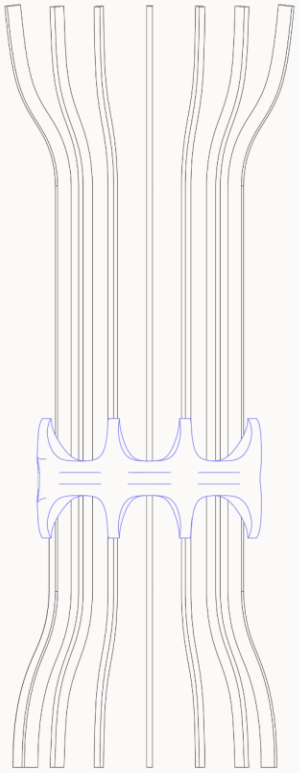
Plan



Front View

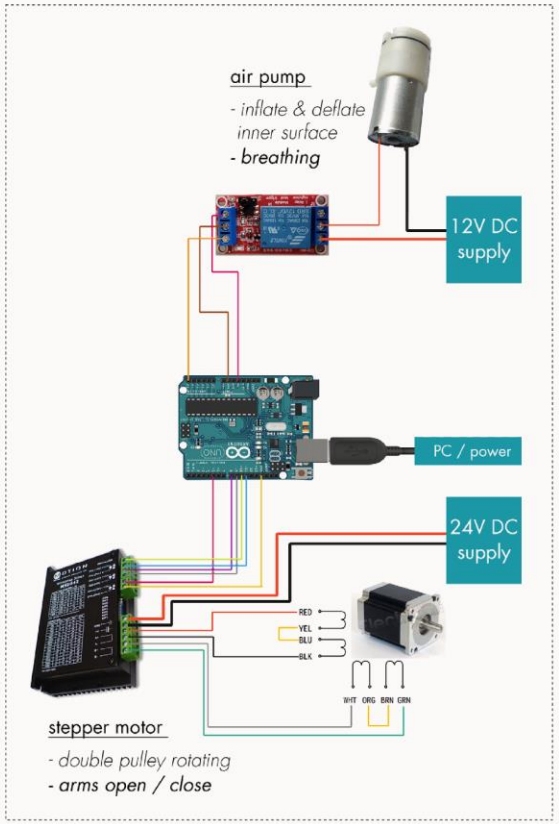


Axonometric

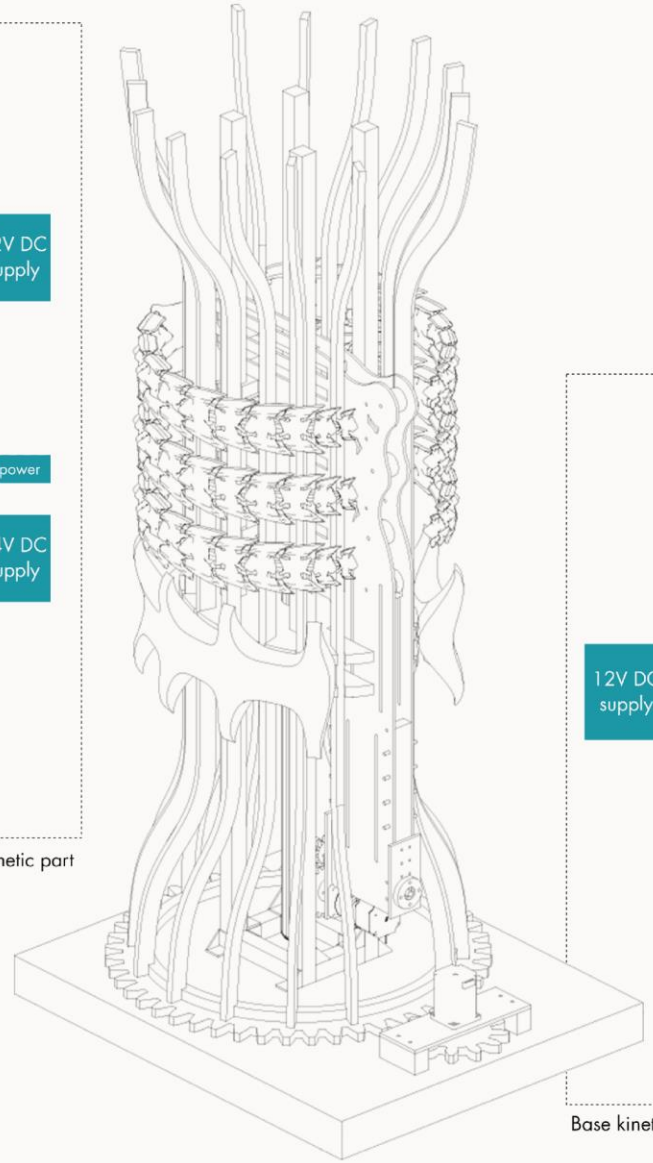


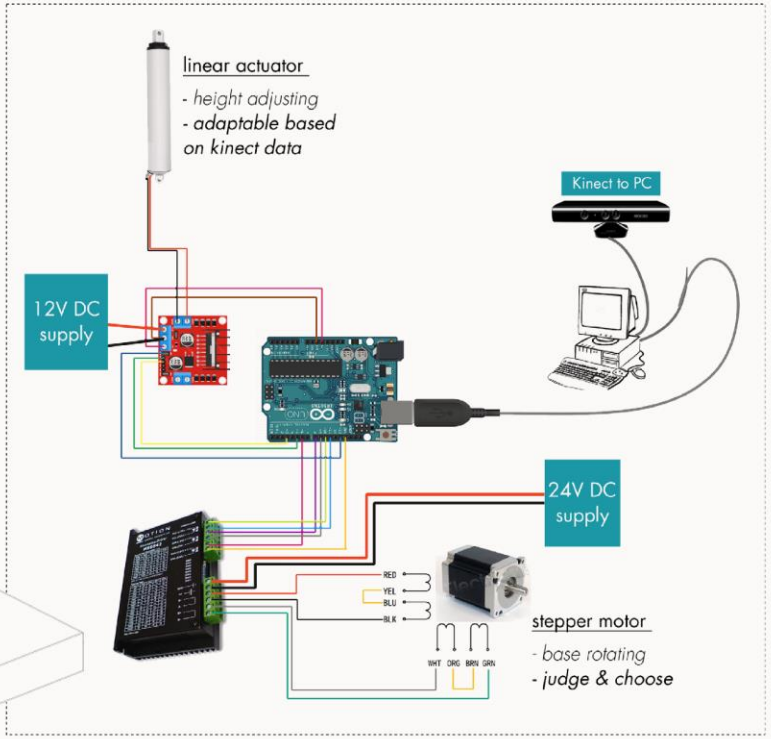
Side View

Electronics Diagram



Height-flex kinetic part





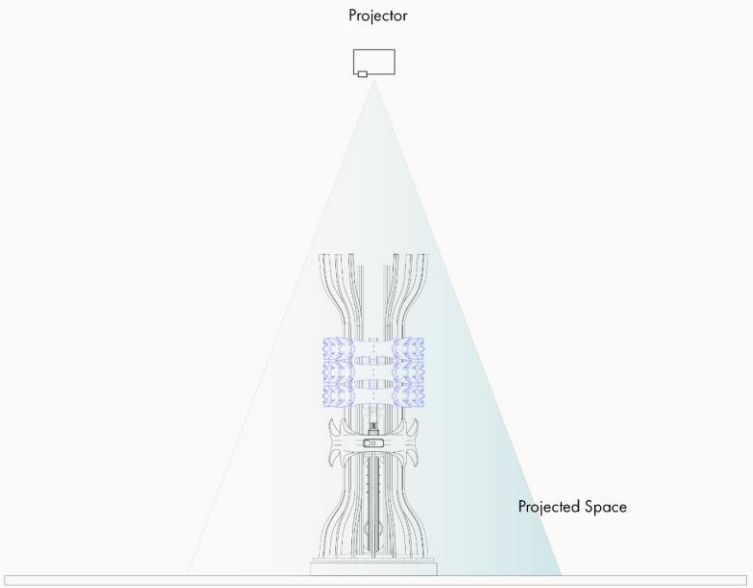
Base kinetic part

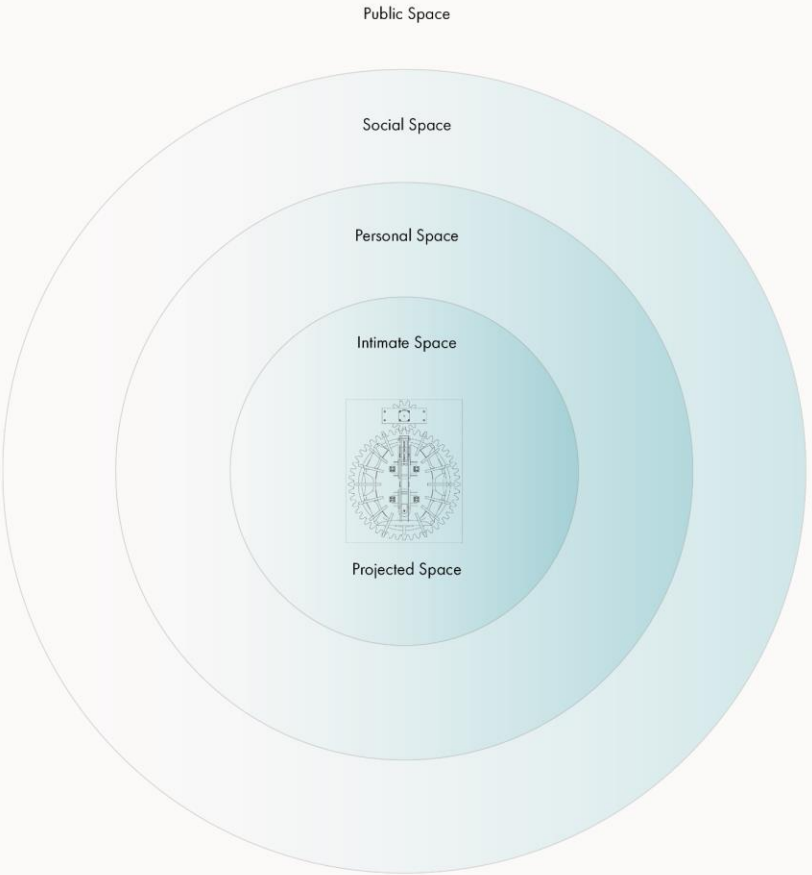
Spatial Layout: Projection Space

A projected space exists around the machine, indicating its modes. The machine starts scanning or judging people based on their proximity to itself. Proxemics refers to the study of how space and distance influence communication and the machine uses this as its basis for judgement among other factors.

Man's sense of space is closely related to his sense of self,which is in an intimate transaction with his environment. Man can be viewed as having visual, kinesthetic, tactile, and thermal aspects of his self which may be either inhibited or encouraged to develop by his environment.

Hall, E. T. (1966). The Hidden Dimension. Garden City, NY: Doubleday.

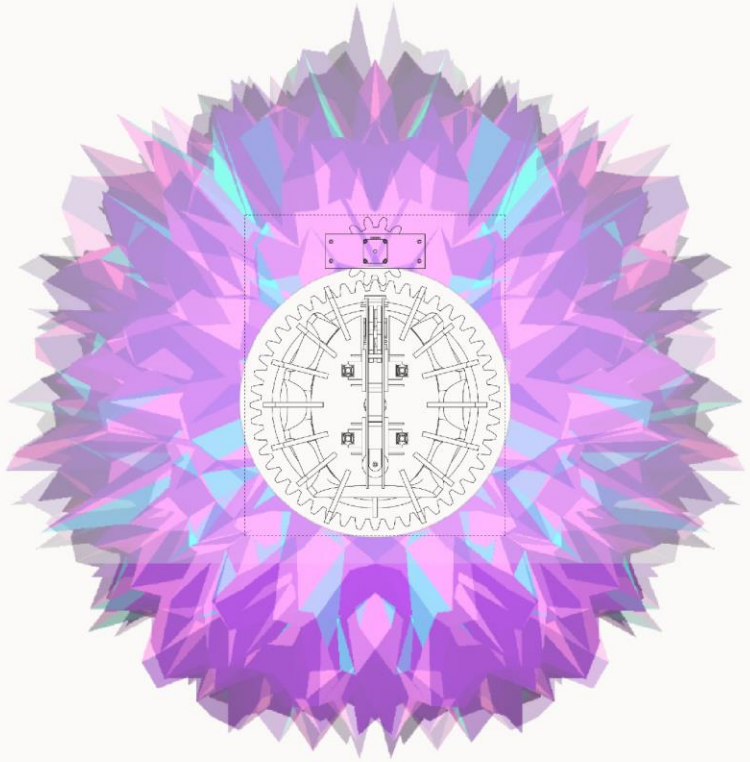




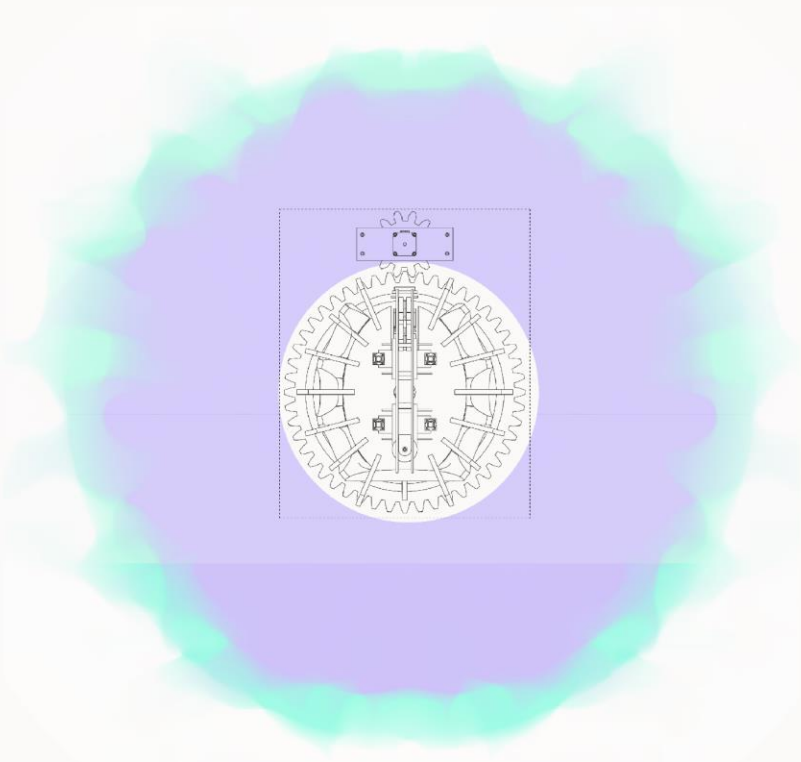
Spatial Layout: Projection Patterns

The different projection colours and patterns indicate which mode the machine is in.

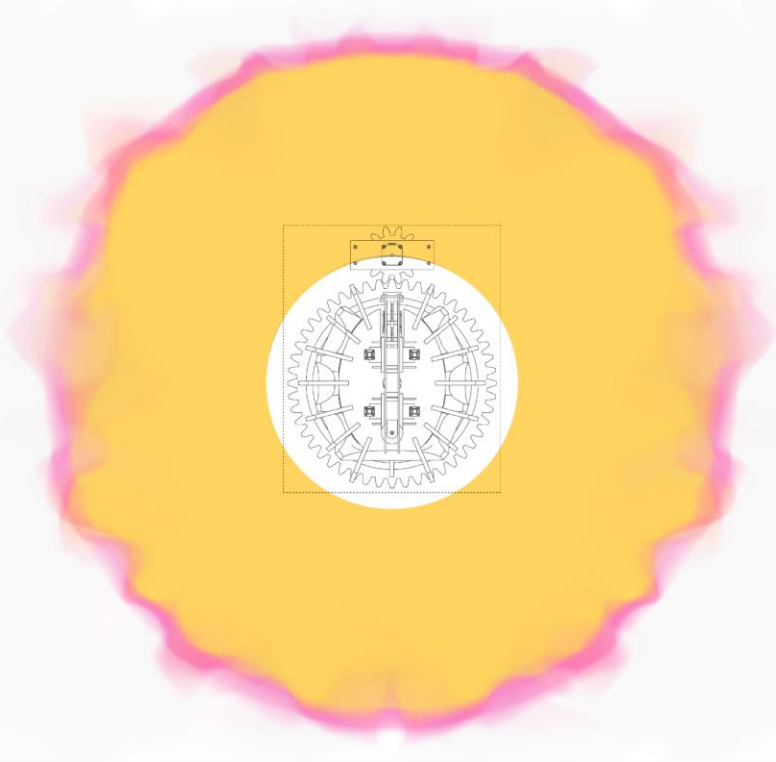
Top View



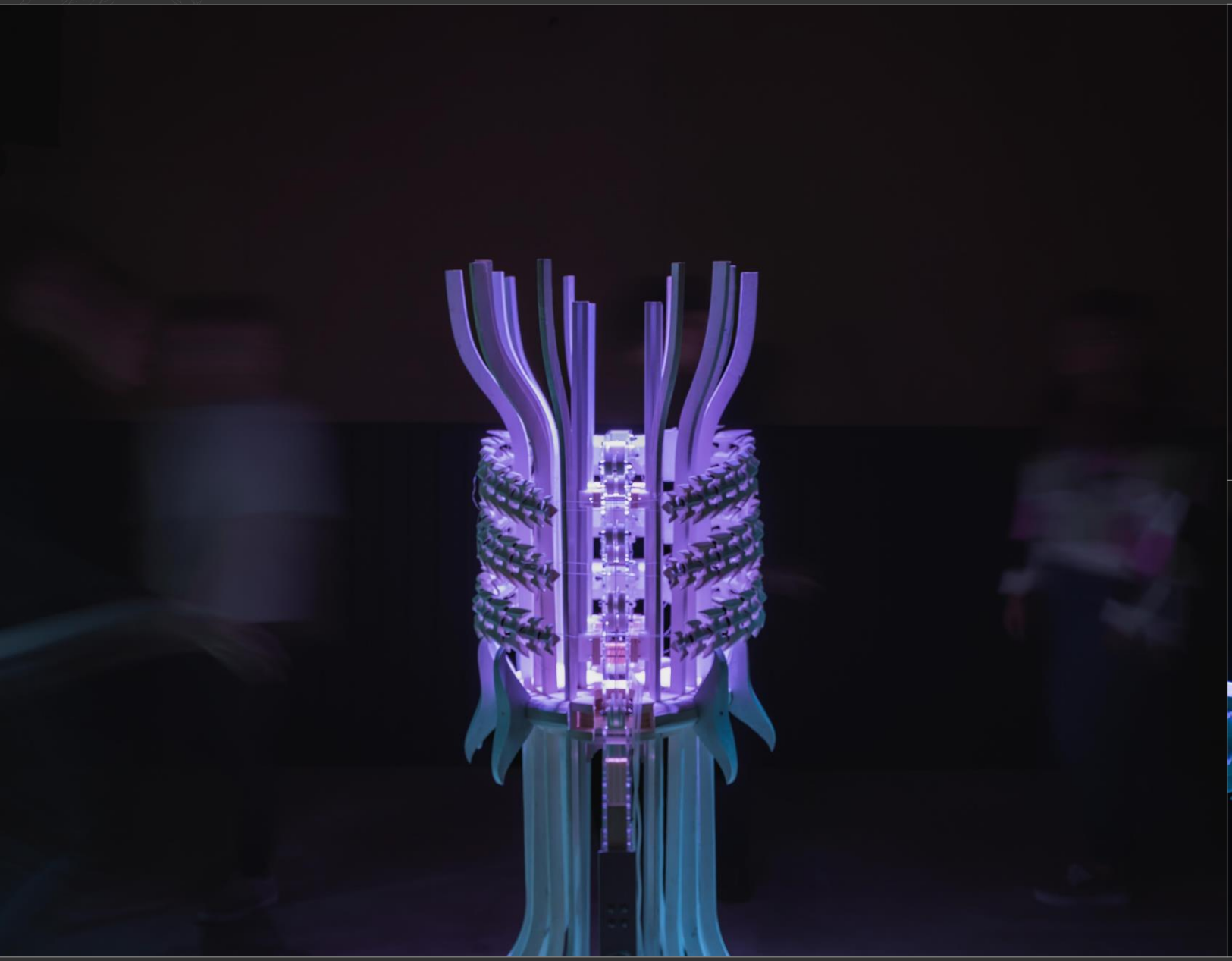
Protection Mode

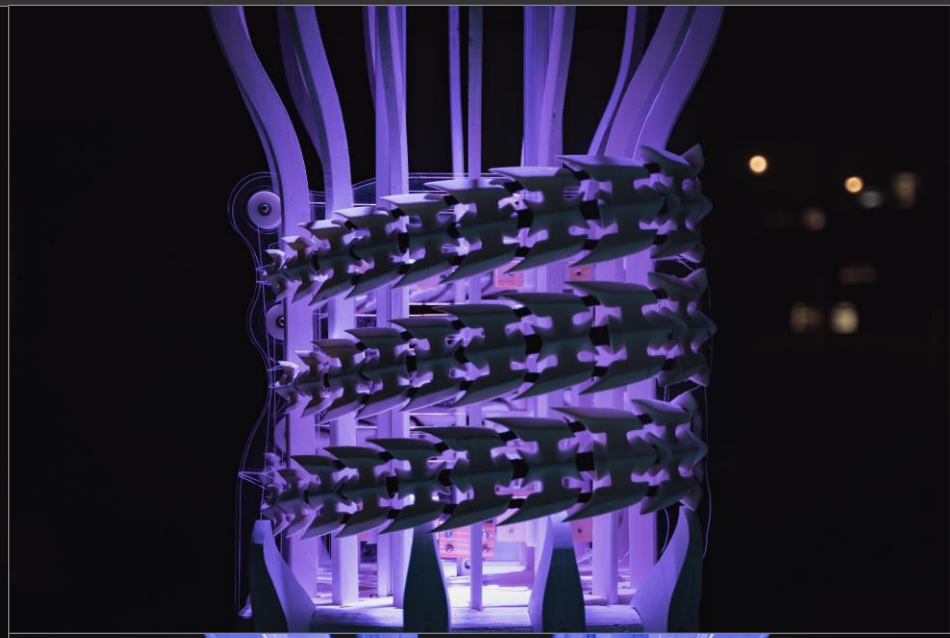


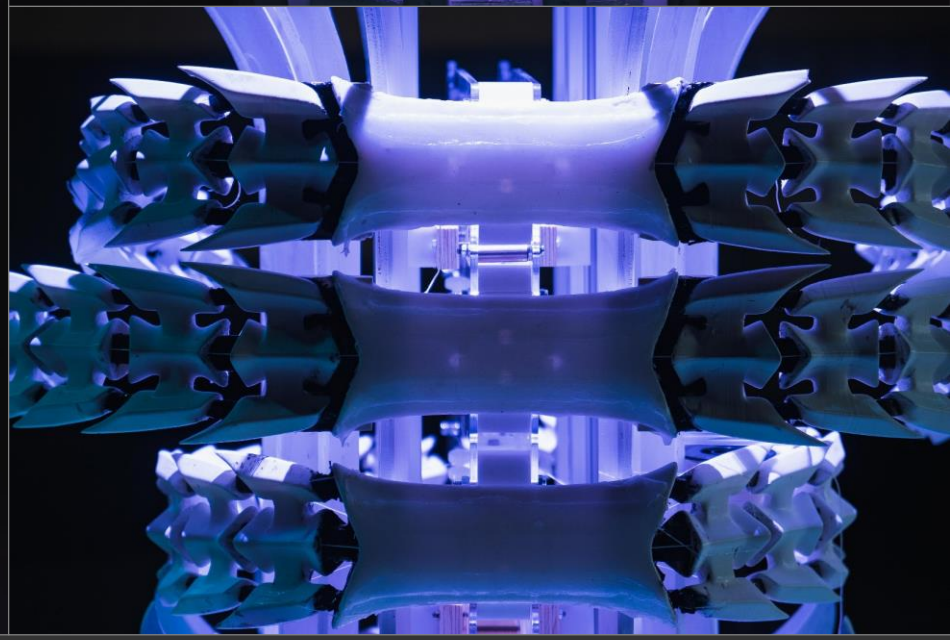
Acceptance Mode

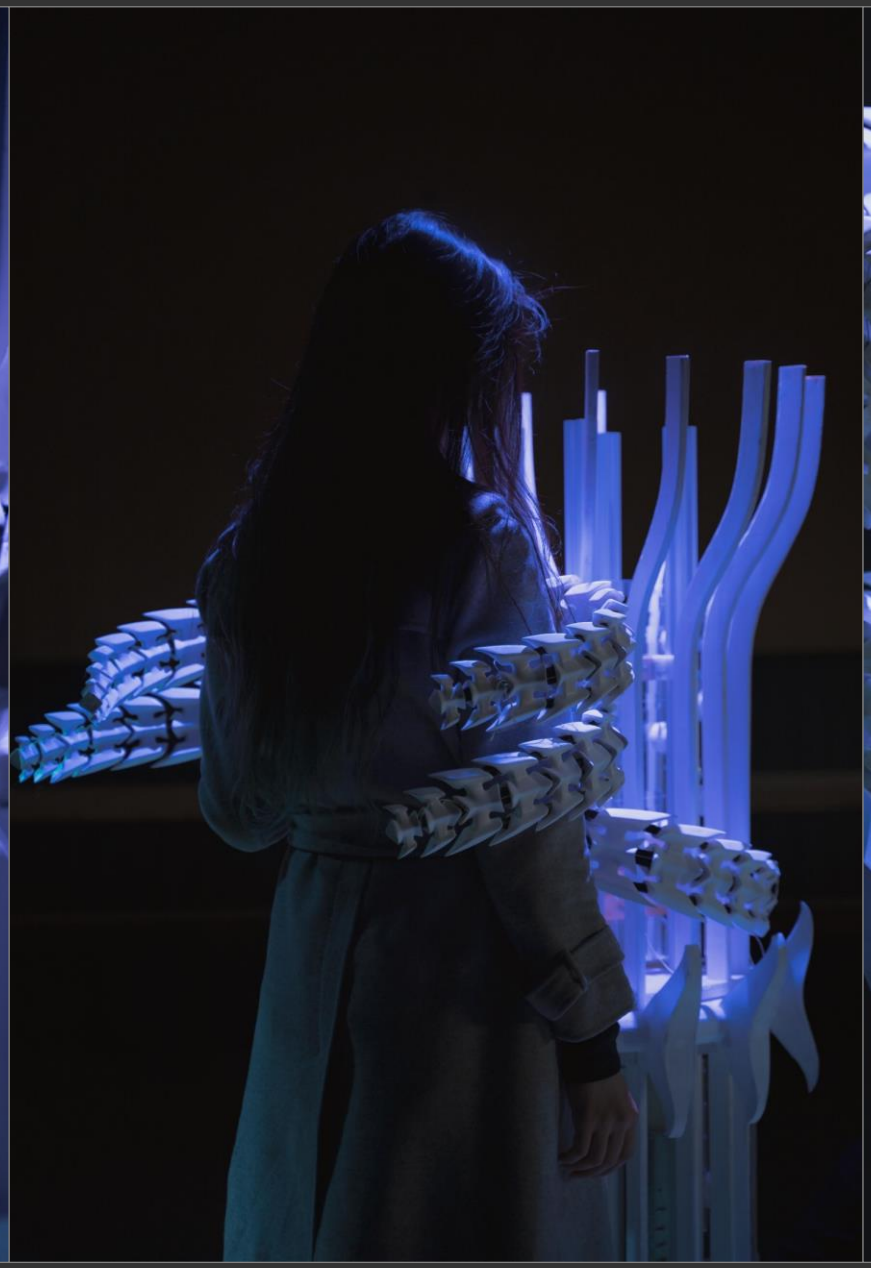


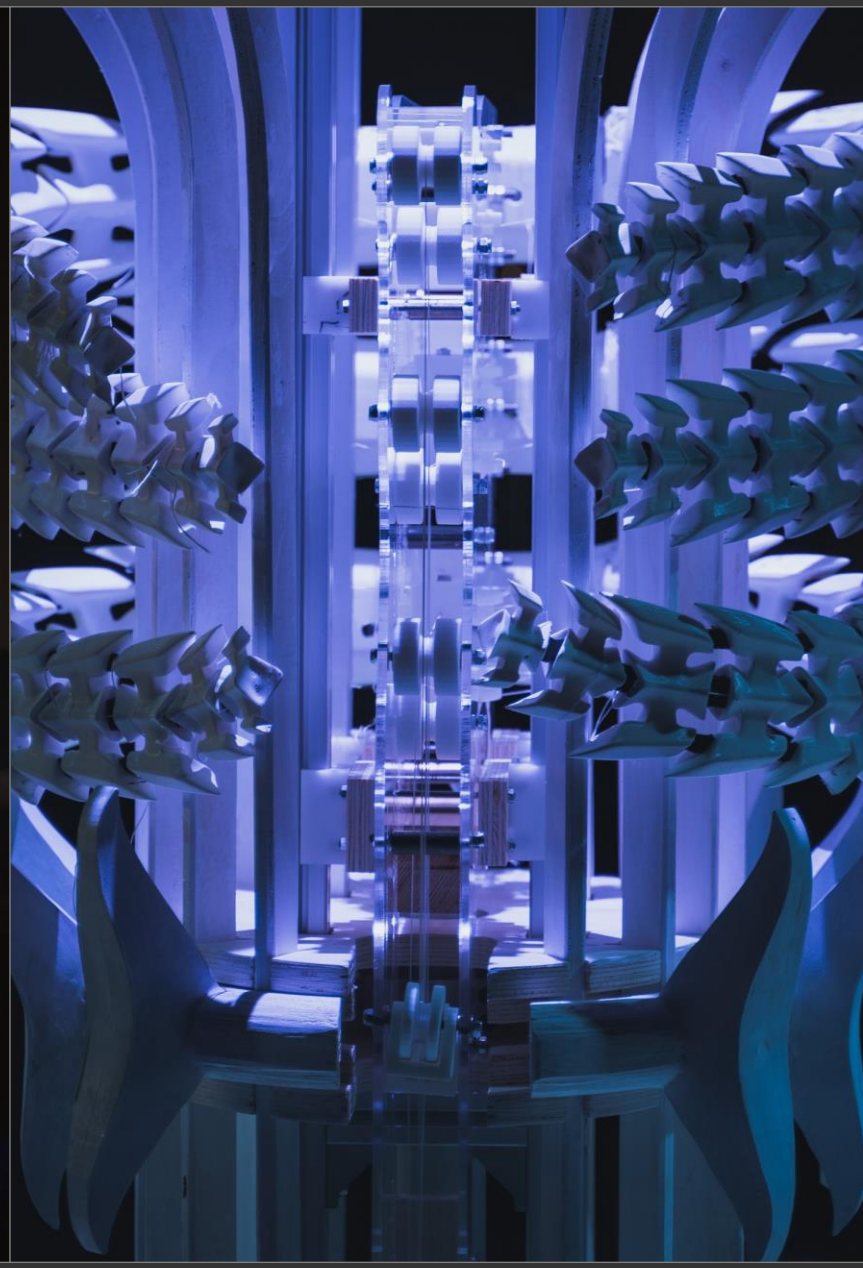
Judging/ Scanning Mode











THESIS

Tangible Future:
Materiality in Embodied Experience

Full text: https://www.bingluu.com/tangiblefuture

Bing Lu

Supervisor: Ava Aghakouchak

KEYWORDS

Materiality; Tangible Media; Haptics; Embodied Experience;
Unpredictability; Uniqueness; Adaptability; Material Intelligence;
Human- Material Interaction

This research questions the homogeneity and perceptual constraints inherent in the embodied experiences facilitated by pre-programmed intangible media across performance, contemporary art, technology and interactive design. I argue that these experiences, with great deduction of uniqueness & real-time presence, result in a monotonous and low-entropy future. The ignorance of perceptual richness and personal embodiment deepens the dualism of body and mind.

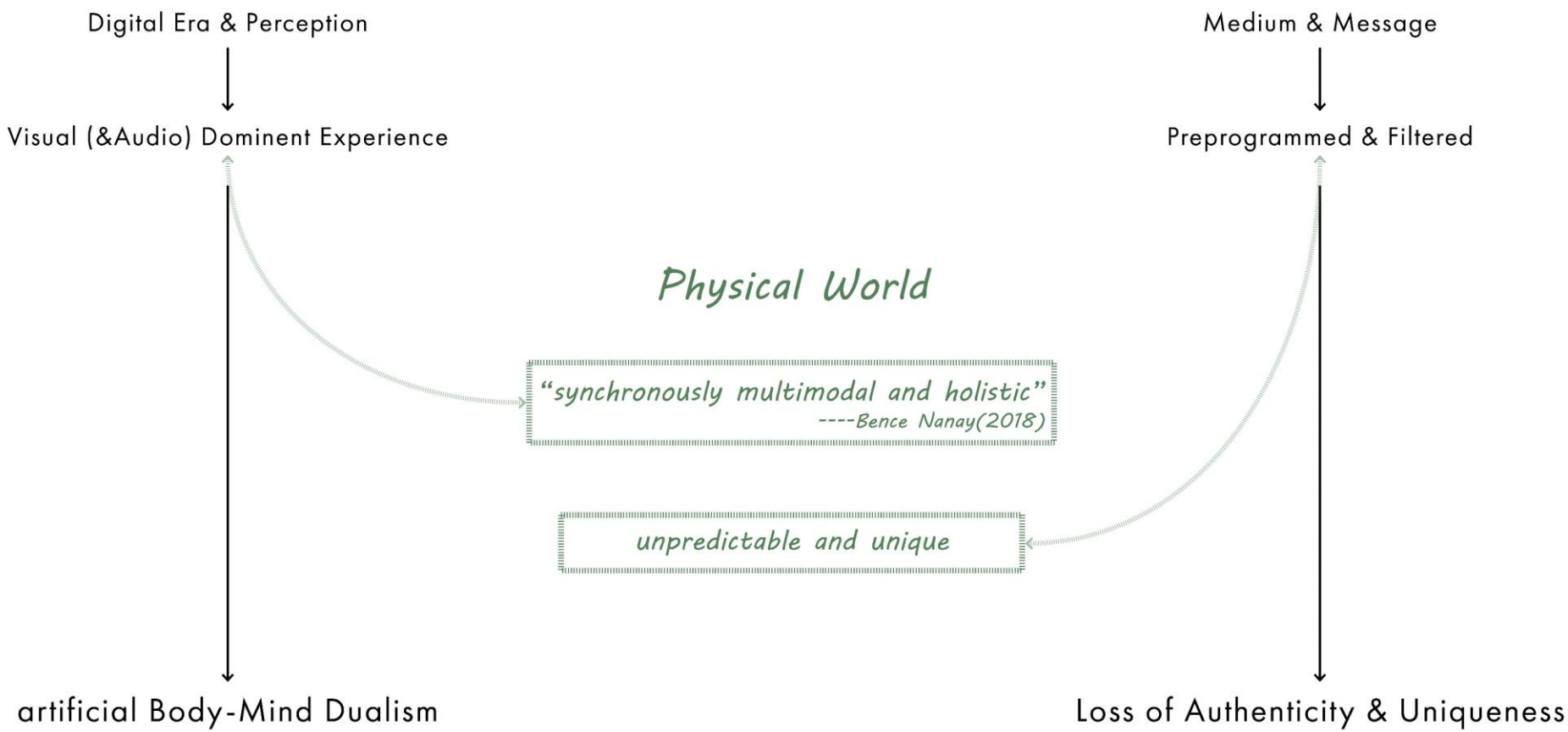
This research tries to draw a picture of a more tangible future in this increasingly digital world. I advocate for enhancing the materiality of all layers of experiences:

- **the Materiality of the Human Body;**
- **the Materiality of Interactive Objects;**
- **the Materiality of the Entire Experience.**

The inclusion of random and personal input re-emphasises the physical existence of the human body. Through the research on soft robotics and adaptive mechanism, she develops systems capable of swiftly responding to unpredictable input. Additionally, through the creation of multisensory encounters, with a particular emphasis on haptics and materiality, she tests how the materials evoke personal emotions and memories, ultimately fostering a reconnection of body and mind.

In conclusion, Bing's research shows how tangible media with an emphasis on haptics has greater potential to restore the uniqueness and authenticity of embodied experiences, leading to the future of **human-material interaction** where reality is enhanced rather than replaced.

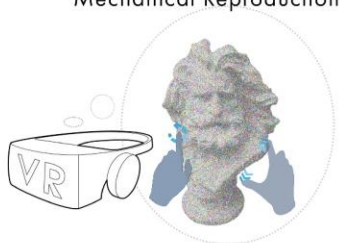
BACKGROUND


Digital Era & Perception
Visual (&Audio) Dominent Experience
artificial Body-Mind Dualism
Medium & Message
Preprogrammed & Filtered
Loss of Authenticity & Uniqueness
Physical World
"synchronously multimodal and holistic"
----Bence Nanay(2018)
unpredictable and unique

Aura: unique presence in time and space[1]

- objects (tangible entities)

Mechanical Reproduction



Visual / Digital Reproduction

- performances (intangible entities)

in Theatre

in Film

Materiality: "the material existence"[2] and its "physical properties"[3].

in Interaction Design:

developing tangible modes of interaction
& integrating computing into material forms[4].

Aura -> Materiality

- of the interactive object
- of the human body
- of the entire experience

1 Benjamin, W. (1968). The Work of Art in the Age of Mechanical Reproduction. In H. Arendt (Ed.), Illuminations (pp. 214-240). London: Fontana.

2 Oxford English Dictionary. (2023, July). Materiality, n.
3 Wikipedia. (2020, February 13). Materiality.
4 Wiberg, M. (2018). The Materiality of Interaction: Notes on the Materials of Interaction Design. The MIT Press

EXPERIENCE

allow ---- *Unpredictability* ---- INPUT

enhance ---- *Adaptability* ---- MECHANISM & CONTROL SYSTEM

create / rediscover ---- *Intelligence* ---- MATERIAL

OBJECT - BODY

Lockdown & Media

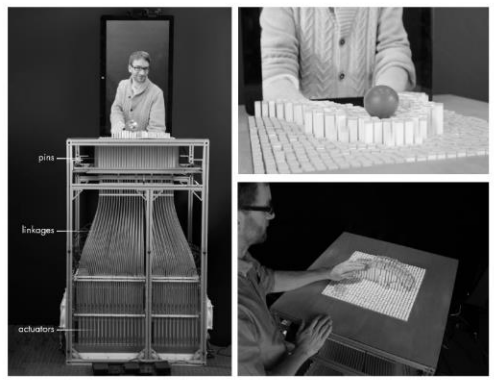
- social media and video communication cannot compensate for normal real-life social[5].
- feelings of loneliness, isolation, and a sense of being adrift which attributed to the touch deprivation in digital interactions.

Tangible Interaction

Tangible Media - Haptics

- haptic simulation for AR / VR

- Tangible Media

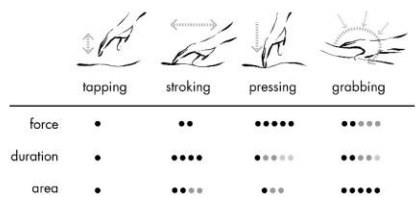


Body, Physical World, and Haptics

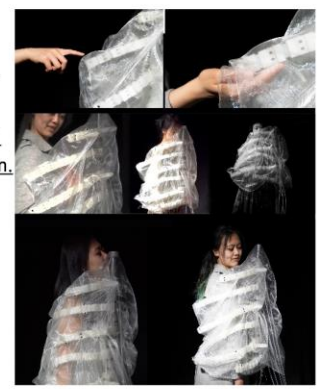
- We inhabit our bodies, living with them and through all their perceptions to know and experience a complex physical world 6.
- Through perception, the body always instinctively engages, focuses and re-acts to the world before any verbal reflection or any thoughts and actions7.
- "Tangibility" characterises this dual nature of touch, where individuals simultaneously engage in both active and passive roles, revealing the inseparable relationship between initiating touch and being touched.
- Haptic perception (through our biggest sensory organ, skin), which is always underestimated, serves as a reminder of the materiality and embodiment of our beings8.

Tangible Embodiment - Haptics

Tactile Actions are :
contact between two surfaces. Different names and meanings come from different contact force, duation and area.
So there`s potential to create various rich haptic experience using simple mechanism.



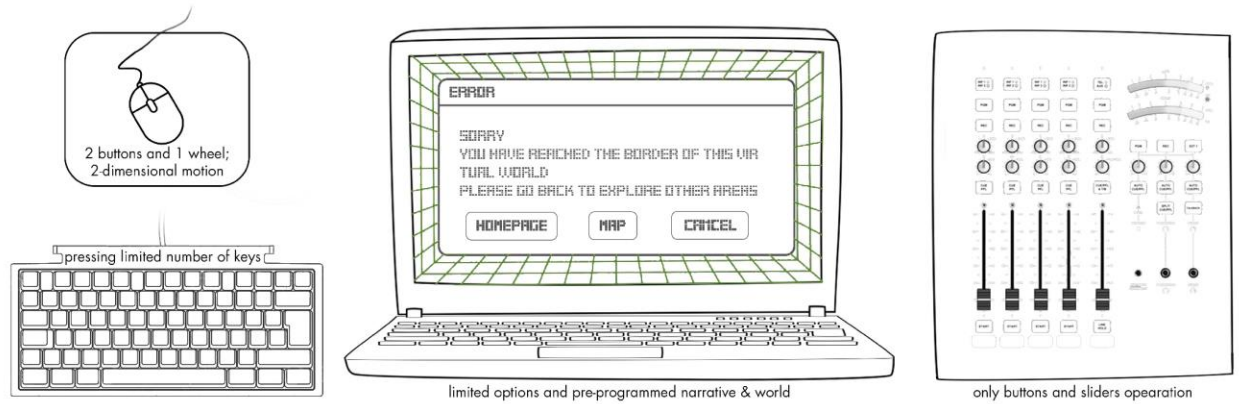
Research on different tactile actions.



Application in our project

5 Brandtzaeg, P. B., & Lüders, M. (2021). Young people's use and experience of the Internet during the COVID-19 lockdown: Well-being and social support. First Monday, 26.

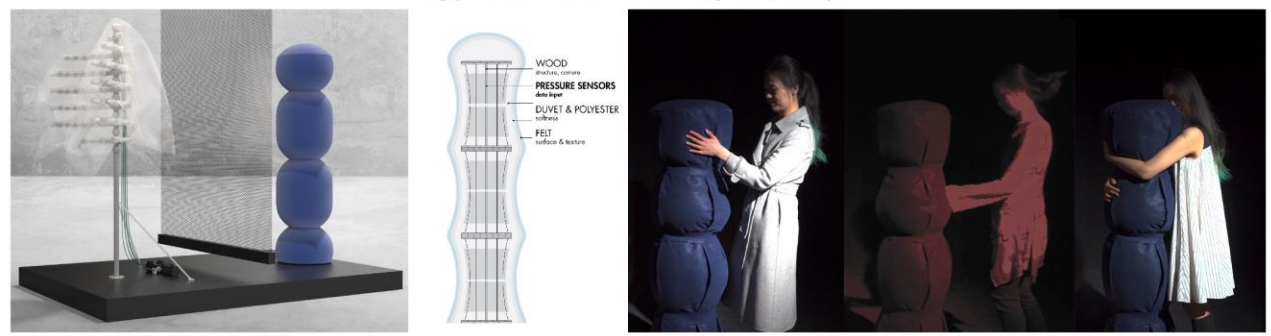
6 Merleau-Ponty, M. (1962). Phenomenology of perception. London: Routledge.
7 Nixon, D. (2020, December 7). The body as mediator.
8 Hornecker, E. (2011). The role of physicality in tangible and embodied interactions. Interactions, 19-23.



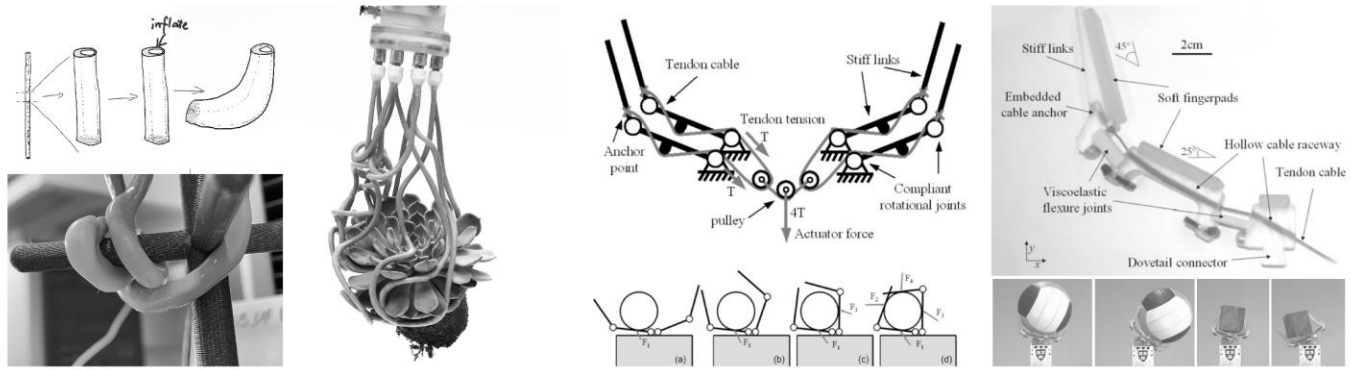
samples of limited & default input

allow ---- *Unpredictability* ---- INPUT

using pressure sensor to record any random input



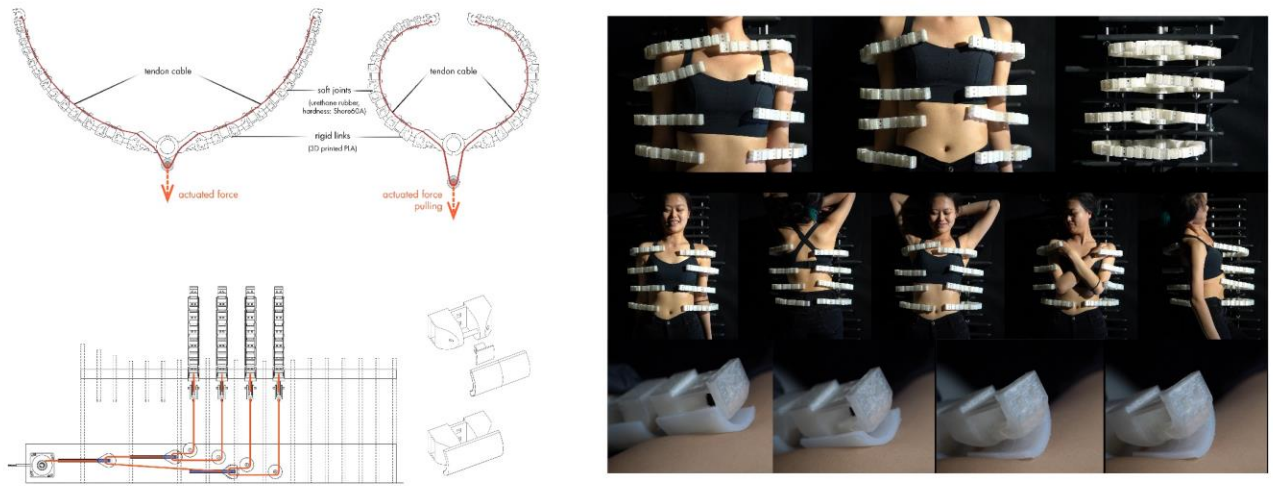
human body as input



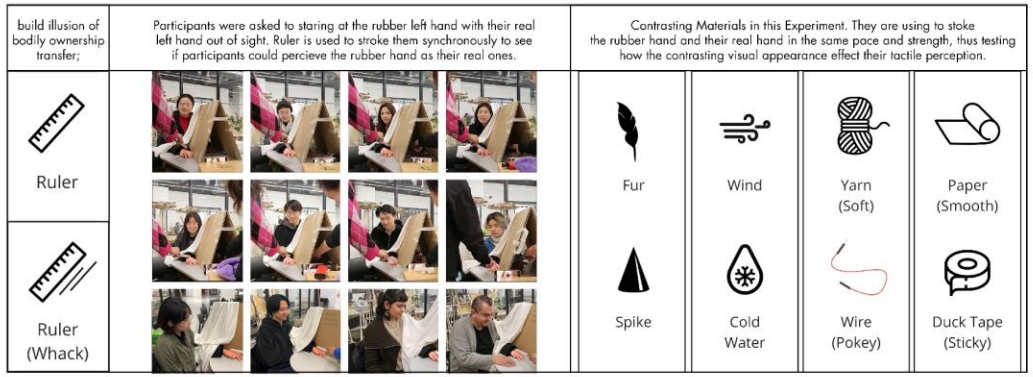
adaptable mechanism study on soft robotics
(inflatable / actuated cable with rigid links)

enhance ---- *Adaptability* ---- MECHANISM & CONTROL SYSTEM

application - installation for LFA



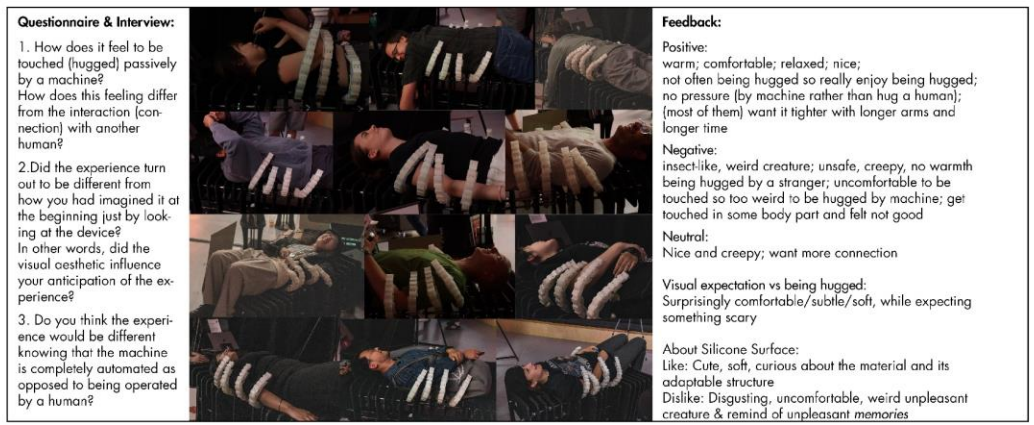
Bing Lu



Material Perceptual Experiment
- contrasting visual appearances and real tactile textures could somehow enhance the tactile experience

create / rediscover ---- *Intelligence* ---- MATERIAL

Feedback of Haptic Mirror in Exhibition
- the contrast between visual appearance and tactile expectations heightened their sensory experiences
- materials have the capability to evoke people`s personal emotions and provide a highly embodied experience



The most profound technologies are those that disappear. They weave themselves into the fabric of everyday life until they are indistinguishable from it.
—Mark Weiser (1991)

Human-Computer Interaction

↓

Human - Material Interaction

individuals &"atoms"world RE-CONNECTION

- Ubiquitous Computing
- Physical Manifestation

» Tangible Interaction
» Embodied Experience

~~*replace the reality*~~
embrace the authenticity & richness of reality