WINNOW
An Interactive Materiality Design Research Process

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ABSTRACT

This pictorial shows the design research process of the design of Winnow; an interactive material. Within the HCI community, more attention is focussed on interactive materials as new interfaces. The design research process includes a material, shape and interaction explorations after which they were combined into a fully experiential prototype. This prototype was used to detail the interaction. Illustrations and photos show the process and explain insights and decisions. In the end, the details of the final design are listed and the process and design are placed in literature.

AUTHORS KEYWORDS

Interactive Material, Interaction, Haptic Visuality, Design Research.

INTRODUCTION

Designing based on a vision requires a different approach since technologies are not yet designed or readily available. However, it does allow for great leaps forward within the HCI community [rad atoms]. One of these visions is the vision by Ishii, Lakatos, Bonanni, and Labrune [6] on radical atoms which is also covered in other research [1,6]. They believe that tangible user interface (TUI) or shape changing interfaces (SCI) will become more present in the future. These tangible interfaces have the advantage over Graphical User Interfaces (GUIs) that they have a richer affordance, speak to our haptic and kinaesthetic senses and support multi-user interaction. In this paper the general term of interactive materials will be used unless talking about the specific research. Since the hypothetical material that Ishii et al. [6] discuss in their paper does not yet exist, a challenge arose when using an embodied design process. The current range of materials cannot easily change shape and hence the interactive material cannot be experienced.

To create these new shape changing materials, technological innovations are needed but they should also be used by designers. Research is being done into how HCI and material science can together create shape changing materials with for example shape memory materials or auxetic patterns [14]. Once a material is able to shift shape it should also incorporate sensing and actuating to become a robotic material [9] or a computational composite [16]. When the material becomes interactive another challenge arrives; the coupling between the input and output is not always present or well designed. Without this coupling the interaction with this product will be non-intuitive [18].

The bidirectional coupling might be missing because the material is not yet capable to change its dynamic form in relation to the digital states and vice versa [6]. Nevertheless, even when the material might be able to do this, the current generation of designers is not educated to work with these materials [1]. In two areas more knowledge and skills are needed.

Firstly, designers have little knowledge about new interactive materials that are being developed and they are hard to get access to or use [11]. Interdisciplinary projects with students from chemistry and physics could be beneficial here. Furthermore, tools to easily design for these shape changing interfaces need to be developed and are already being developed [10]. A balance needs to be found by designers between a basic knowledge which allows them to communicate to expert and a ready-at-hand knowledge for how to design with these materials without having the formal understanding. Projects and courses can help designers to find this new attitude.

The second area which requires attention is how to design for the temporal form [16, 17]. While designers are educated to design aesthetic products, the aesthetic element of the interaction and especially the temporal form are less often discussed. This temporality of the form and the interplay between all properties makes it a complex design challenge [1].

Due to its temporal nature, interactive materials and especially the relation between their physical form and the temporal form, and the temporal form and interaction gestalt are hard to capture and describe [16]. Using an alternating view between optic and haptic visuality makes it already better possible to describe the physical form and non-aesthetic qualities [8, 14].

However optic and haptic visuality do not involve touch, while this is the most holistic way to experience and judge the aesthetic qualities of something tangible [14]. The temporality of the computer and the temporality of the input/ output compositions determine the temporal form of the computational composite [17]. However, the temporality of the humans and society influence how we experience them which shows that it is essential for the full understanding. Hummels, Overbeek and Klooster [5] also showed the importance of bodily involvement and that this is a skill that needs to be trained. This aspect of training and gaining tacit knowledge in movement to fully appreciate the aesthetics of an interaction is not always present in research that discuss TUIs or shape changing interfaces [4, 15].

An interesting relation and parallel can be found between the introduction of interactive materials and machine learning (ML), a field in which I am personally interested. ML is another field within HCI that gains more attention, and which is being used more frequently [19]. Working with ML requires a different attitude since it is based on statistics to make sense of big data. On the one hand interactive materials can support designers because also in this field more education and design tools are needed [3]. The advantage of using interactive materials is that they can carry more information, communicate it clearer than their two-dimensional equivalent [7] and allow for multi-user input [1]. On the other hand, ML can be used to program interactive materials. The variety of possible inputs and interactions makes it complex to program the behaviour of interactive materials heuristically. ML can be a solution since it can create models for implicit problems. However, ML is not omniscient and when something goes wrong it can be hard to find the reason [19].

INSPIRATION

Inspiration during the design research process of Winnow was found in nature: the mating dances of birds; the colours of a peacock and the blossoms of tree. The transition of something discreet to more exuberant and vice versa was something that initiated the design process and established the transition for the material: from timid to extrovert.

This pictorial describes and shows the research process of the creation of Winnow, an interactive material. The transition was used as starting but was abandoned in the synthesising phase. Existing materials and possible shapes and interactions were explored and made into a computational composite by adding electronics. At the end of this paper the process, results, possible future steps and learning points are discussed.

Figure 1 - Inspiration from peacock. Photo by Public Domain Pictures via Pexels

Figure 2 - Inspiration from blossom. Photo by Guilherme Rossi via Pexels

DESIGN PROCESS

Material Exploration

During the design process, the start of every iteration always included exploring the properties and qualities of different materials. The choice of materials has been essential to achieve the right aesthetic qualities, perception and movement.


Figure 3 - Collected Inspiring Materials


Figure 4 - Sample of Materials Further Explored


Figure 5 - Workshop Sketching Transitions

Shape Exploration

After choosing a certain material, shape exploration and annotations helped to gain better insight into the possibilities the material had to offer and the techniques which could be applied to this material. The exploration was often inspired by shapes found in nature.


Figure 6 - Flower Shape Exploration


Figure 7 - Shifting Layers Shape Exploration

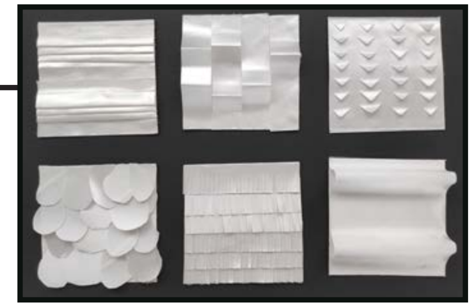
Figure 8 - Material Texture Exploration

Interaction & Movement

Following the shape, was testing the interaction and possible movements the shape could produce, combined with the programmed technology. This included testing if the complete design was durable, able to restore itself and created a fitting interactive experience for the user.

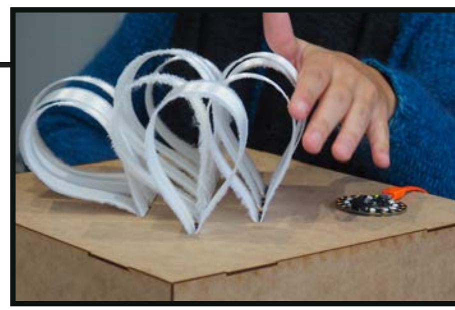
Figure 9- Experimenting Interaction with Sensor


Figure 10 - Interaction Soft Frayed Edges


Figure 11 - Analysing Interaction

Detailing

This final phase was about evaluating the specifics. It included a significant amount of reflection and evaluation about what the design represents, what experience it can offer and how it could be improved. Based on this assessment, an improved iteration would be made.

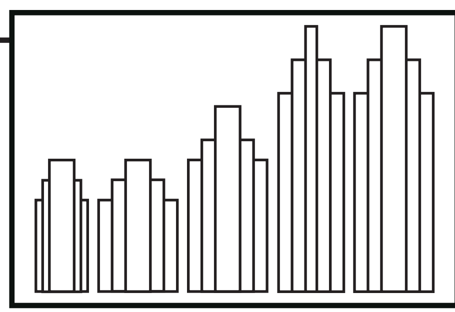
Figure 12 - Exploration Size Loops


Figure 13 - Exploration of Shape as Texture


Figure 14 - Frayed Edges

ANALYSIS – Material & Shape Explorations

Figure 15 - Fan Shaped Exploration

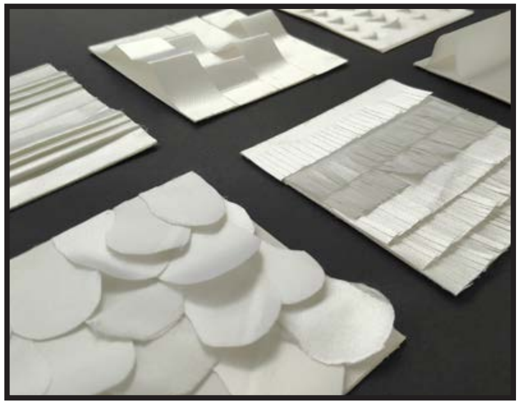

Figure 16 - Material Texture Exploration

Figure 17 - Satin Fabric

Figure 18 - Satin Texture

During the workshop on *sketching transitions in dynamic form from a materiality perspective*, it was the first opportunity to explore with the use of different materials and different shapes. After choosing to work with satin, different material properties, shapes and texture were explored and created.

The satin was chosen because of its shine which makes that its appearance changes when moving or when the lighting condition changes. The shine was also quite extrovert and fitted well with the transition since the haptic visuality [8] would already show part of the nature of the fabric.

Figure 19 - Experimenting Techniques

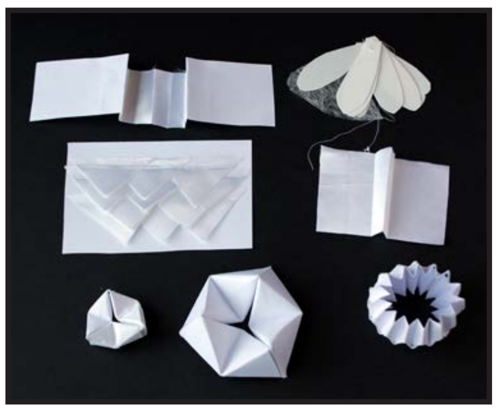

Figure 20 - Shape Explorations

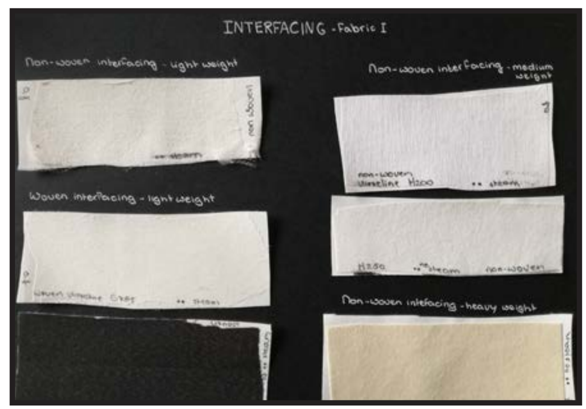

Figure 21 - Interfacing Fabric I

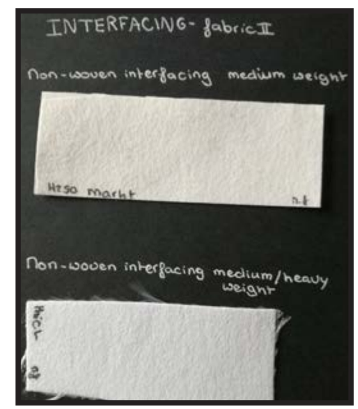

Figure 22 - Interfacing Fabric II

Different fabrication techniques were tried with the chosen material. Such as the use of 3d-printing, laser cutting, sewing and ironing. Most shape explorations were done with the satin or with paper. The satin itself was too weak and needed some kind of support.

It was desirable to give the satin the same or more stiffness as paper so it could stay in shape. Through the addition of a layer of interfacing the same properties were tried to achieve. Different types of interfacing were explored. The criteria for the interfacing was that it should provide enough support and stiffness to create the shape. Furthermore it should not show the traces from previous use.

ANALYSIS – Material & Shape Explorations

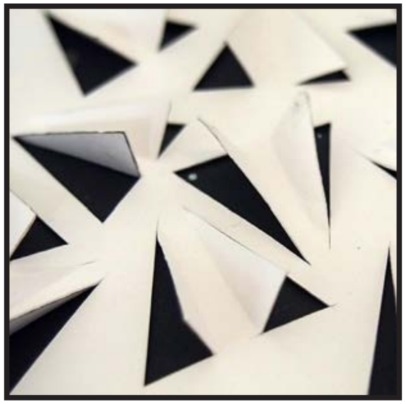
Figure 23 - Pattern Shape Texture

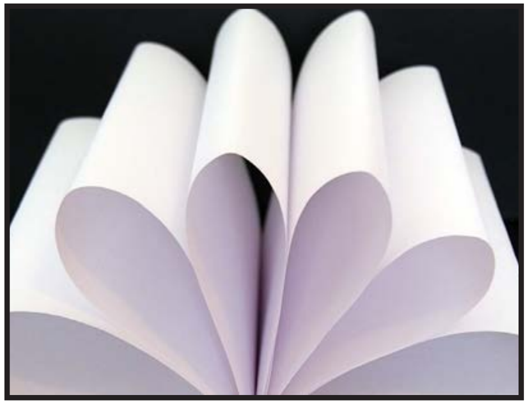
Figure 24 - First Chosen Shape


Figure 25 - Chosen Shape with Decovil

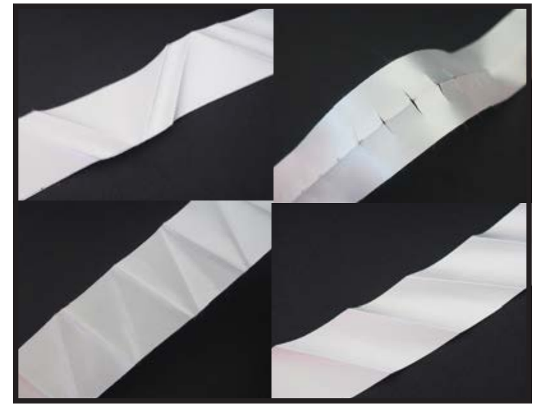
Figure 26 - Reinforcement Patterns

Through shape explorations, the choice was eventually made to use multiple loops. What triggered the choice for this shape was the transition of timid to extrovert, by moving the shape up and down, the form, affordance and dynamics changed. In this moment of decision, the interaction and transition were essential.

Figure 24 was the first paper representation of the shape. Figure 25 was the following iteration of the same shape that was chosen for the final design. After choosing this loop shape, different textures were explored to make the shape more intriguing and improve the structure of the material (figure 26). However, it proved to be too bold therefore, it was not implemented.

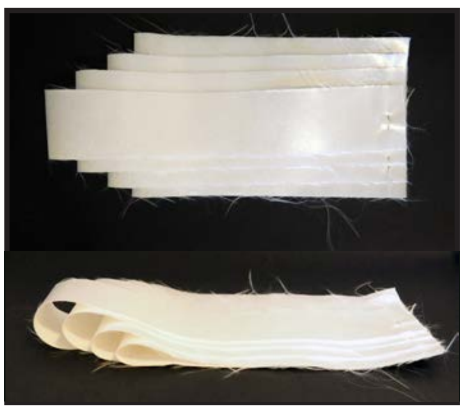
Figure 27 - H250

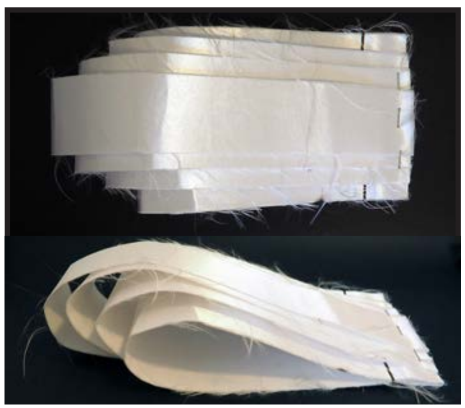
Figure 28 - Decovil light

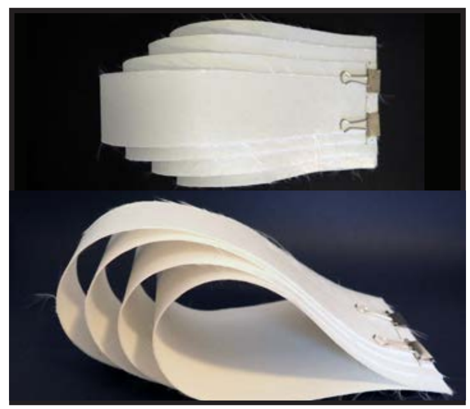
Figure 29 - S520

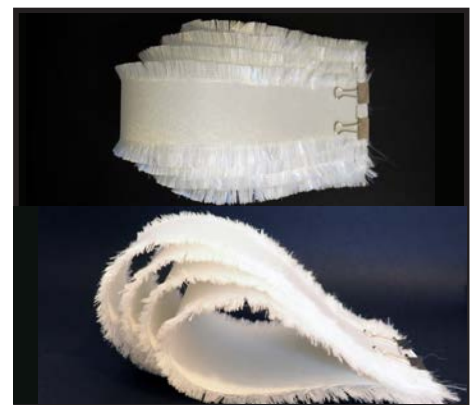
Figure 30 - S520 with Frayed Edges

Three types of interfacing were tested for the final form; H250 was not strong enough (figure 27), Decovil light was stiff enough but showed creases and the decision was made to use Vlieseline S520 since this showed the best properties. It was stiff enough to create the desired shape and it was able to transfer the dynamic bounce between multiple loops without showing traces of use.

With the right combination of fabric and interfacing the edges started fraying when cut with scissors. This was the inspiration to explore and design the edges. Frays showing the matt warp threads were chosen because they create a contrast which emphasises the shine of the fabric. Next to that, the frays make the edges very soft to touch and invite people to touch it.

ANALYSIS – Interaction

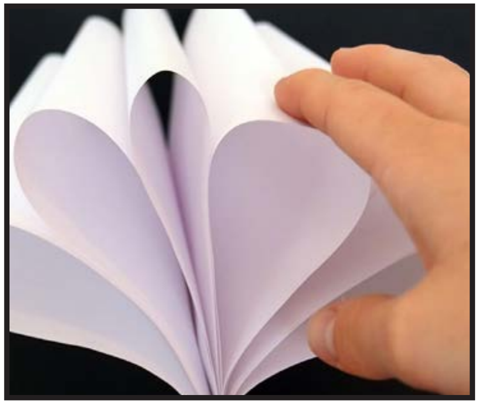

Figure 31 - Shape Interaction

Figure 32 - Example Construction

Figure 33 - Construction Vertical Movement

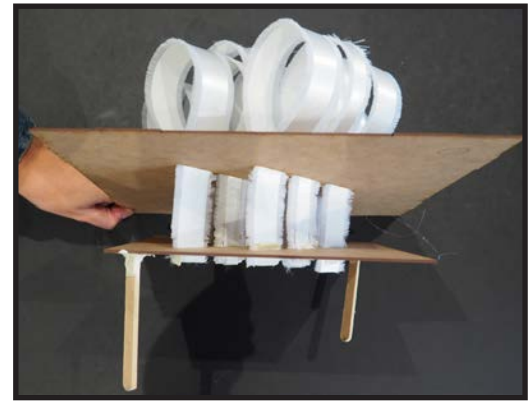

Figure 34 - Final Construction

The first iteration of the interaction was one were the loops could be deformed, wave and move up and down. For this a construction was made with two plates. The loops were attached to the bottom plate which also actuated the movement. In the extroverted state, the loops are larger, more flexible and thus allow more movement. When pulled down, in the timid state, the loops are smaller and stiffer.

A servomotor attached to the construction of figure 33 would allow this vertical movement. However, the horizontal and vertical movement interfered with each other, which resulted in a overly complicated mechanism. Moreover, feedback revealed that purely the horizontal movement was already interesting enough. Therefore, the decision was made to focus solely on the horizontal movement.

Figure 35 - Exploring Interactions

Figure 36 - Exploring Interactions

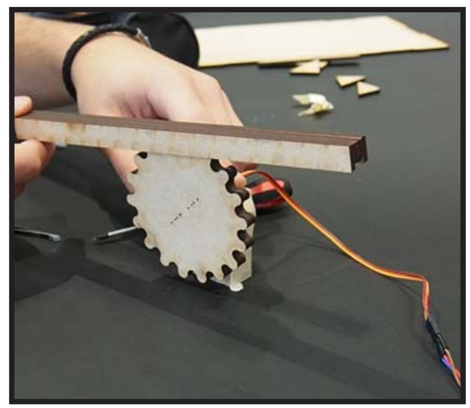

Figure 37 - Final Mechanism Movement

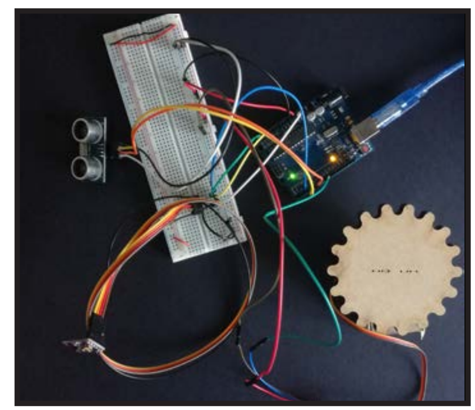

Figure 38 - Testing the Sensors

The haptic visuality of the shape and material invites two interactions: First of which, is a short, one finger flick against the outside of a single loop which transfers the dynamic energy to the following in line. The other interaction is a movement with the whole hand which involves petting and touching all loops. Both interactions can be done when the user is in close proximity to the material.

Inspired by the theory of perceptual crossing [2], the second iteration of the interaction was divided in two phases: 1) An irregular wave-like movement of the loops to attract attention. 2) A subtle movement to follow or move against the hand motion. To actuate these movements, a gear with a servomotor, an ultransonic sensor to measure the distance and an RGB gesture sensor would be used.

SYNTHESIS

To create a holistic interactive material design, the physical form, temporal form and interaction gestalt should be in harmony [16]. Therefore, the three analyses are combined into one single design. Further explorations with this physical form (figure 40) lead to the conclusion that the design looked more like a single object.

Upon reflection, the use of a texture was favourable for multiple reasons. First of all, the physical form of this object only invited a two-dimensional interaction. A texture provokes interactions from all directions. Secondly, a material texture is more open to other interpretations which makes it easier to implement in a future specific context. Lastly, the goal of this design research process was to design an interactive material, not a singular interactive object. This is because interactive materials could be considered as the interface of everyday life products.

The shift from an object to a texture resulted in the same selection of desired material properties and qualities. Furthermore, the positioning of the loops should be parallel on both axis in order to transfer the dynamic energy as described in previous explorations.

Experiencing the interaction demonstrated that the user has a myriad of options which makes designing the interaction more complex than expected [1]. Therefore it was essential to keep the mechanics and electronics simple so this could be optimised but still capture the richness of human interaction.

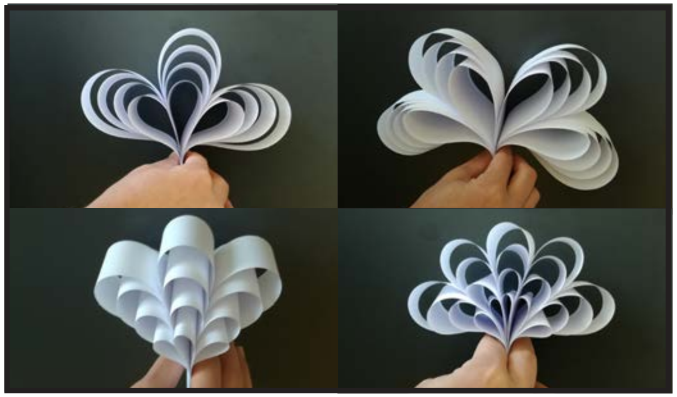
Figure 39 - Exploration Layering


Figure 40 - Final Single Object

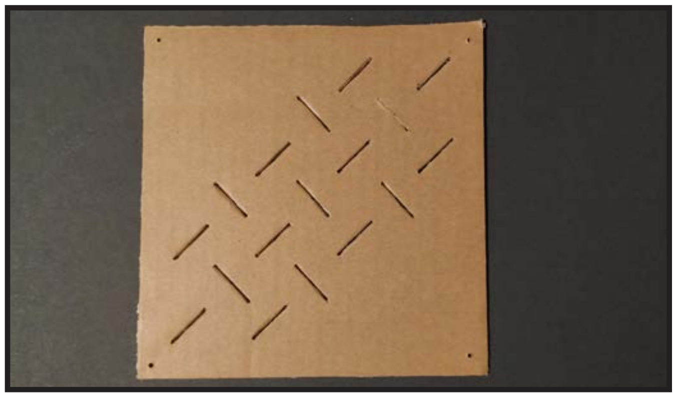
Figure 41 - Perpendicular Pattern

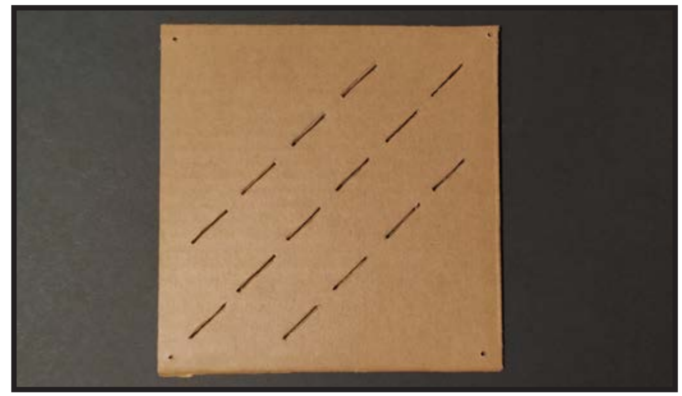
Figure 42 - Parallel Pattern

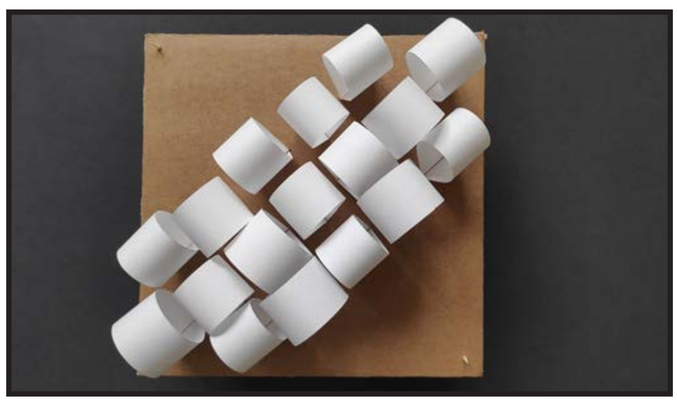
Figure 43 - Exploration Texture Direction Loops (perpendicular pattern)

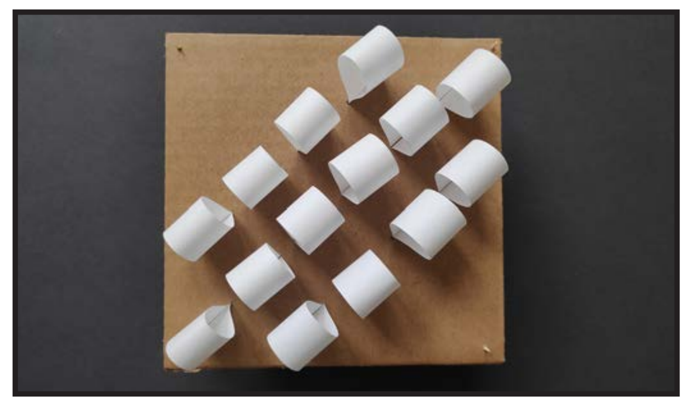
Figure 44 - Exploration Texture Pattern (parallel pattern)

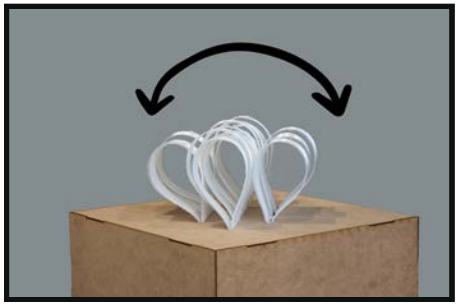

Figure 45 - Initial sway Winnow when nothing is detected.

Figure 46 - Quick sway to grab attention when nothing is detected.

Figure 47 - Reaction to hand gesture.

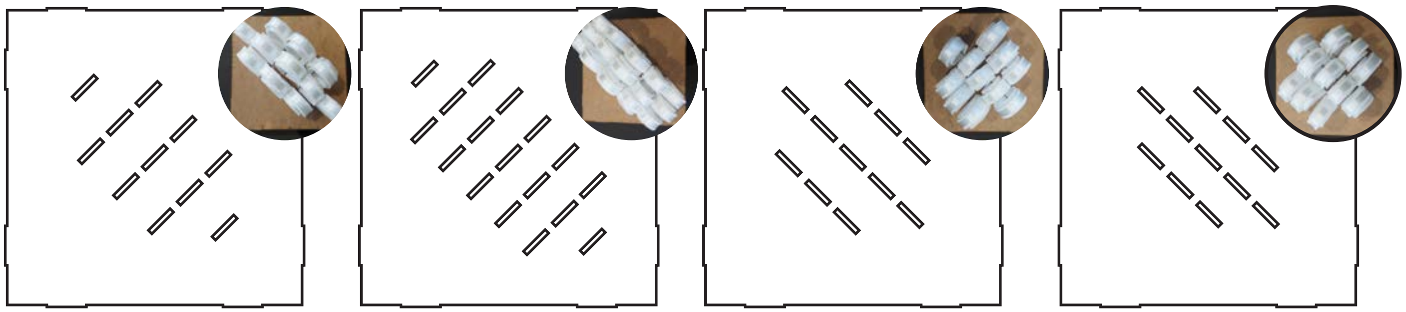

Figure 48 - Exploration of the pattern and spacing, the final pattern can be seen on the far right.

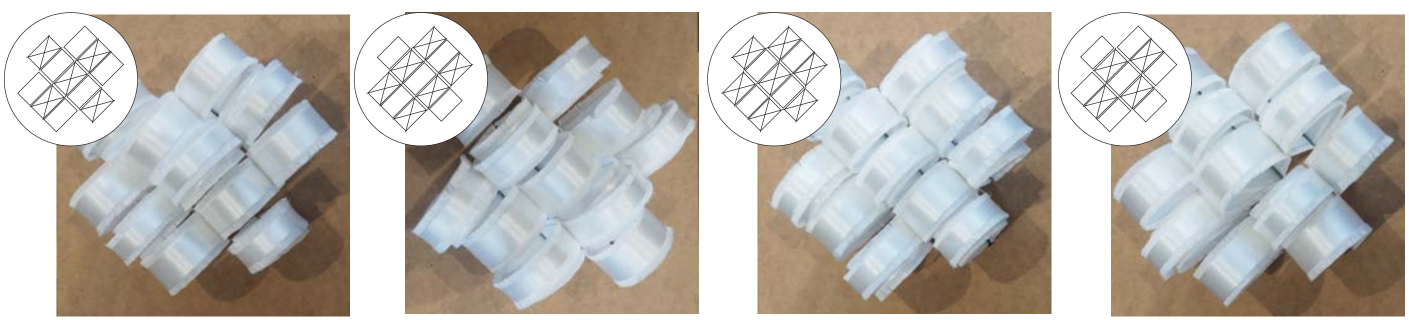

Figure 49 - Experimenting with the use of layers (cross = double layer), the final layering pattern can be seen on the far right.

DETAILING

Interaction & Movement

The interaction was one of the most challenging aspects of this project because of all the different options possible. After a trial and error process of using different sensors to realize the three main interactions shown in figure 45, 46 and 47, an ultrasonic sensor was chosen to sense the distance between Winnow and the user. It was not feasible to detect the hand gesture above the loops because the action is executed from above and not from the side. The materials appearance needs to be maintained and the interaction should be feasible in every context, therefore light sensors and conductive wires were not an option. Hence, the desired final interaction is designed by using one reliable distance sensor which couples the location of the user to the dynamics of Winnow [18].

Pattern & Spacing

To create a more dynamic look the decision was made to use a diagonal pattern. The spacing between the loops had an impact on the bounciness and translation of movement between the loops. As this trait was desirable, the decision was made to go for a 4 cm spacing.

Use of Layers

Layers were used to create more volume, stiffness and intrigue within the texture. Different samples and patterns were tested and the decision was made that the inner placed loops should be double layered. As a result, it created more volume at the center of the whole.

FINAL DESIGN – Winnow

The material
Material name: Satin & Vlieseline S520

Design Technique: Heat press or iron

Electronic Features: Ultrasonic sensor (HC-SR04) and Servo motor (Futaba S3003).

The behaviour
Winnow will measure the distance of a person that is in front of the system. As long as the sensor does not detect anyone in a proximity of 150 cm, the texture sways horizontally. To create novelty for the voyeuristic experience [17] and to attract people the movement occassionaly speeds up. When a person comes within the 150 cm range of Winnow, the frequency of the swaying movement will increase as the user comes closer. Within arm length (40 cm) the movement will stop and the loops will return to the upright, 90 degree position. This provides users the freedom of interaction to fully experience the material. After a certain amount of interaction time, Winnow will perform a sudden fast shake urging the user to go away and leave it alone. When the user leaves, it will return to the initial undisturbed swaying movement.

The electronics
There is an ultrasonic sensor (HC-SR04) located on the front of the box, which measures the distance of a person in relation to Winnow. A servo motor (Futaba S3003) powers the movement of the loops swaying from side to side along a sine wave, the motor is attached to a gear which is transmitted to a track that moves the plane with loops attached from one side to the other.

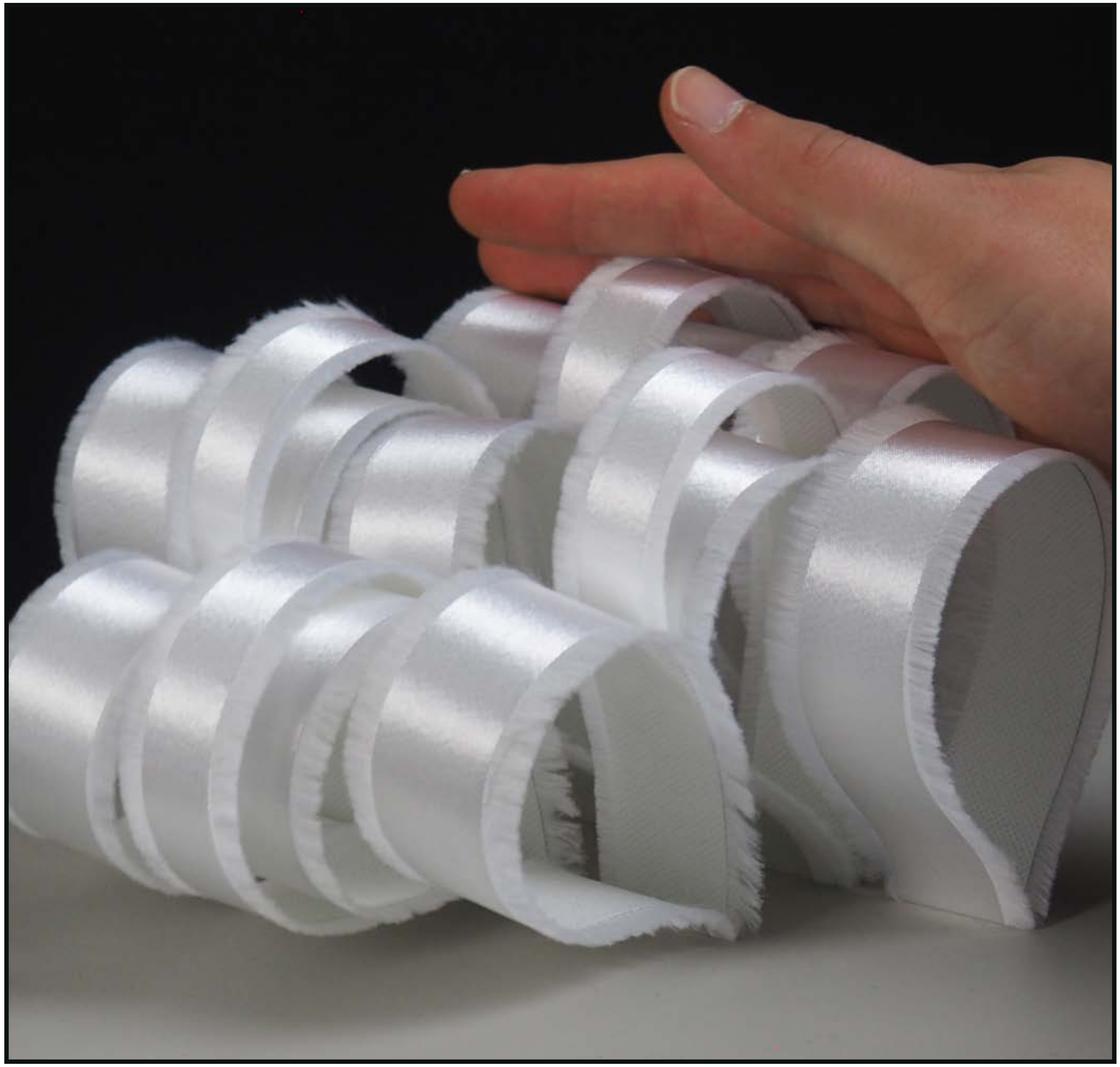

Figure 50 - Winnow : Final Design Interactive Material

DISCUSSION

The contribution of this paper is in the field of designing for interactive materials. Winnow can be classified as a computational composite; both the material and electronic elements are necessary for the design to become useful. It is open for discussion if Winnow is a real interactive material because the material itself cannot sense; its haptic components will feel the same, but its temporal form will change over time. Nevertheless, it helps to explore what elements are important when designing SCI. Interesting next steps would be to see how interactive materials could be applied in a context such as data physicalisation. The decision to switch to a material makes that I can more easily imagine different applications and contexts of use.

Figure 51 - Winnow : Final Design Interactive Material

Key in the process was a learning by doing approach and constantly reflecting on the results. The different visions in our groups made that we were able to look more holistically at the material and to learn from each other's expertise. I personally believe that the learning curve and results could have benefitted even more when working inter-disciplinary as described in the introduction. However, as a group we, perhaps too late, realised how difficult it is to design for an interaction and that a different approach was needed. We were able to change attitude and really focus on one small element instead of all the ambitious plans we had.

As written in the introduction I see similarities between designing in the two emerging fields of SCI and ML. The latter will be the focus during my master, and I think that is equally important there to first focus on one element and later generalize the findings instead of getting overwhelmed with all possibilities.

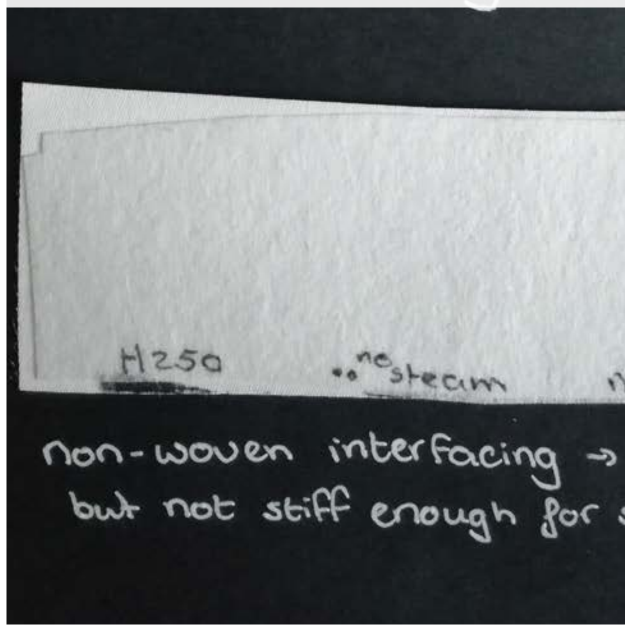

Figure 52 - Annotations

My interest in interactive material is a combination of two almost conflicting interests of mine. On the one hand I am analytical, structured and my first reaction is to observe. My skills are also in programming, data analysis and finding patterns and links to literature. On the other hand, I do value embodied interaction and always strive for it during projects. This project forced me to involve all my senses and trust my intuition. By being critical I was able to learn what I, and we as group, considered aesthetic. Approaching this with my normal rational attitude did not work, the experience aspect was key. However, I also saw that my analytical approach was of value when programming and realizing the interaction; for this I needed to see it with an abstract perspective but to evaluate you need to switch attitude and experience it.

Figure 53 - Interaction with Winnow

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APPENDIX 1 – Feedback

Cluster round 1

Material

- Is it fluffy? Does it feel like satin? Why does some have 2 layers? Is it because of the interaction?
- I like the contrast between the glossiness to the outer edges which are none feathery- like
- The beautiful pattern, material curious about how to interact with. Maybe it can't be pressed, just touch softly
- The inside shows the construction of the material which makes it look unfinished? The sides (fluffy) invite touch, but the shiny seems kind of cheap.
- The shiny ribbons in combinations with the furry edges gives a graceful and relaxed feel. The material slooks strong engouh to explore without braking it. But does not look harsh or cold. I get an "angel" feeling. It looks sumpy, like I would touch it

Form or pattern

- Interesting to see the different cutouts. Apparently you chose for a medium amount of them. Not sure why though
- The position and the density of the ribbon gives different imaginations about how it works and feels
- Did you do the width randomly on purpose? I like the random rhythm. Also do they move up & down at the same time?
- Have you tried different patterns? Shell form. Visually the rovels look a bit cheap (but it feels soft)
- The sloths make me think the loops can move in. I am afraid that I might get stuck in the loop when it retracts
- I'm triggered to pull them out or lift them up like lifting up a bag.
- Reminds me of a peacock, I hope that it will shake and surprise me. The chosen pattern does make it look more static.

Interaction

- Looks soft, fun and inviting. Yet not sure what it does? What is the interaction?
- The satin ribbons and bows look like a soft and luxurious interaction. It does feel like it has some sharpness to it. It feels inviting to put you hand on top. So it will give a massage
- If all "flops" move individually would create a very nice effect.
- It looks like the loopies will move up and down in a pattern.
- The material appears soft and very movable. I immediately make the associations of moving my hand through grass/ a pillow with pointy things The different orientations also look interesting. Inviting to touch
- Looks soft and inviting. I want to touch it and push it, or going with my hands through it. Or tickle the sides.
- I like the edges. It would be interesting to see different heights. For me that would be more inviting to touch/ interact
- Funny look, playful, the edges look really inviting to touch, if their size would be smaller. Would it maybe even more inviting? Like it's some sort of fur? Also more inviting
- Looks very soft and inviting to touch. Interested in what it will do/ how it will react. Perhaps shape the box so that it also invites.
- Looks like: soft, inviting touch and tactile interaction
- It invites me to try and pull it out by the shape, but with the satin material "tells" me (personally) to do it softly or with care. After looking more at it, it also looks like I should also pet it carefully.

Random

- It looks like a gift box. And I think it will move up and down because the ends do not seem fixt to the box

Cluster round 2

Material

- Why did you decide to use a material that is pretty stiff? - less playful, less wild
- It feels hard and more rough than I thought it would be, I really like the soft sides, it makes it more softer
- Why did you choose this material?

Interaction

- Interaction is playful, especially the springy effect of the material itself. Wondering if that will be kept if you will control it with the Arduino.
- Interesting combination of materials. The soft of the satin with the stiffer material. I wasn't expecting it to be so resistant. My first instinct for interaction was to go carefully but after learning it could resist I could go in with more fare.
- If you approach it aggressively would it "act" scared or be aggressive by moving fast as well?
- Why does a fast movement evoke force in the opposite direction? What does the side lining of the material intent to evoke - to me it evokes stroking the sides not the ...?
- How about approaching it from the side, and stick your hand in it?
- You tried many patterns of how to fix your material, also think about the possibilities of how people will interact with it
- It looks etheric like you can move your hand through. The matrix makes it less linear, but the interactions feel linear. Can it do something that contrast with the expected movement in the directions. The sides are most inviting to touch.
- Has a very natural interaction . did not expect the bows to feel this sturdy. Do you want to give it an aggressive feel with sudden movements or with the shape of the hand?
- I expected it to be way more flowy. That it would move better with my hands. It looks so soft and airy. The feeling didn't match my expectations. The edges of the things did feel soft

Movement

- How do you make the movement more dramatically change?
- How will it show that it does not like your touch? Could be interesting to include a shake

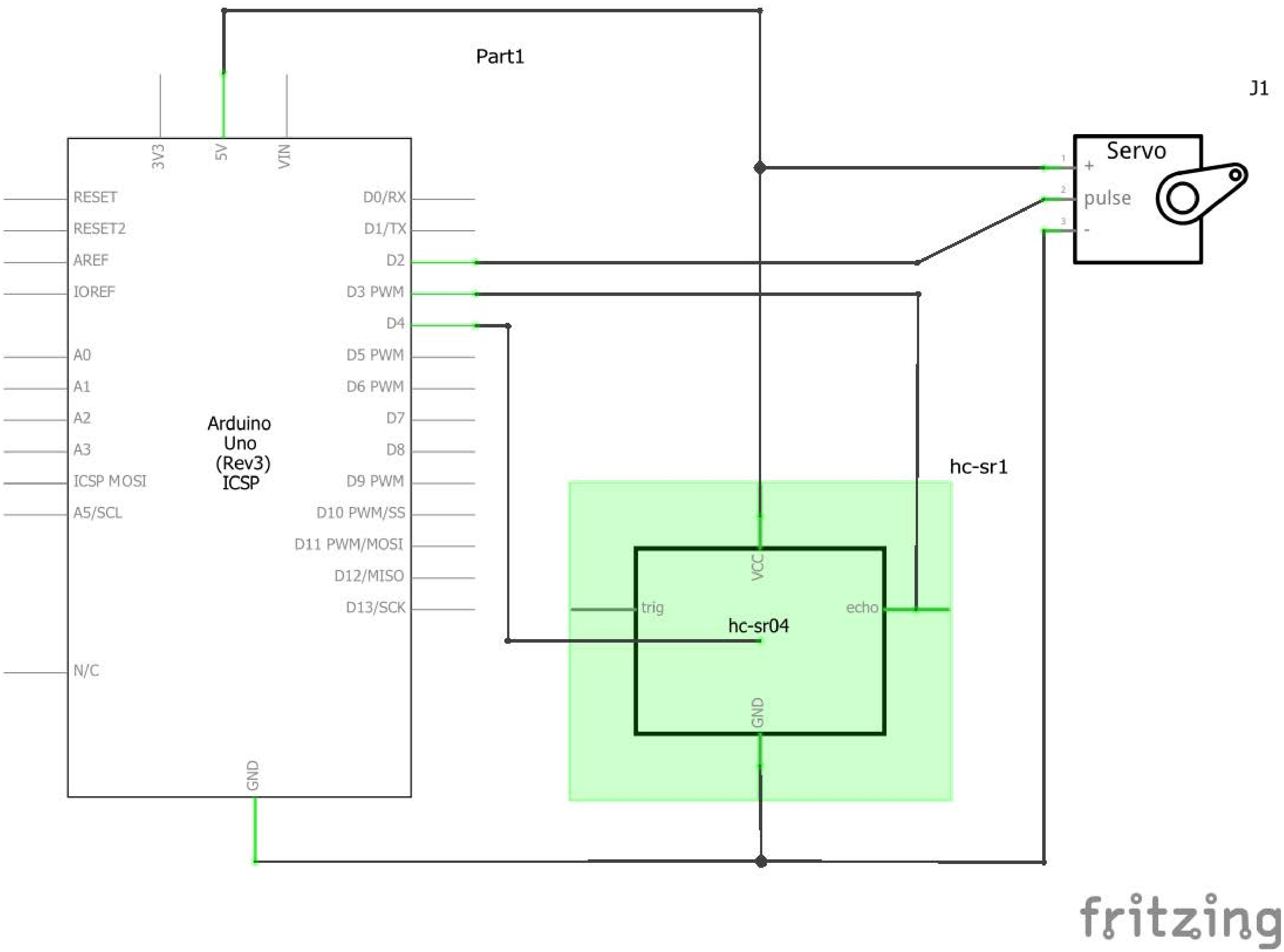
Form and pattern

- The density and the materials chosen invite me to touch it in certain ways
- Feels nice - bouncy and soft. The effect of a touch becomes larges because the rest is under tension . Maybe place more thingies that could fill up the space. It seems to clumsy. Maybe you can hide the mdf with the textile? It might form more of a unified experience.
- Rabbit ear? But I didn't understand the rhythm of the wave . Also I think the ear is a little bit too big (or say it's a litte bit too long) it is really cute
- What is the relation between one vs the whole? The size does not match with my hand/ fingers/ two hands. What feeling should interacting with give? Think about the emotional experience
- Do you think it would be better to try different height possibility, but It may be need more pattern

Random

- It gives me comfortable impressions - like seaweeds.
- Try to make a connection between the sensing and the movement - why?
- How does it sense? Why use this material?

APPENDIX 2 – Wireframe Schematic



APPENDIX 3 – Arduino Code

```
// Code for ultrasonic sensor from: https://create.
    arduino.cc/projecthub/abdularbi17/ultrasonic-
    sensor-hc-sr04-with-arduino-tutorial-327ff6

#include <Wire.h>
#include <SparkFun_APDS9960.h>

// Pins
#define APDS9960_INT    2 // Needs to be an interrupt
    pin
#include <Servo.h>

#define echoPin 3 // attach pin D2 Arduino to pin Echo
    of HC-SR04
#define trigPin 4 //attach pin D3 Arduino to pin Trig of
    HC-SR04
float value = 0;
int servoPos;

#define servoPin 9
// defines variables
long duration; // variable for the duration of sound
    wave travel
int distance; // variable for the distance measurement
Servo myServo1;

long timer = millis();
boolean startTime = false;
boolean shortMov=false;

boolean moveToLeft = false;
boolean moveToRight = false;
boolean firstTrigger = true;
// Constants

void setup() {

  // Set interrupt pin as input
  pinMode(APDS9960_INT, INPUT);
  myServo1.attach(servoPin);
  pinMode(trigPin, OUTPUT); // Sets the trigPin as an
    OUTPUT
  pinMode(echoPin, INPUT); // Sets the echoPin as an
    INPUT
  myServo1.attach(servoPin);

  // Initialize Serial port
  Serial.begin(9600);

 // myServo1.write(servoPos);
  delay(15);
}

void loop() {
  dist();
  //Serial.println(servoPos);

  if (distance > 40) {
   firstTrigger = true;
   Serial.println("Move sinus servo");
   servoMovement();

  }
  else {
   moveTo90(servoPos);
   if (!startTime) {
     timer = millis();
     startTime = true;
   }
   if (millis() - timer > 12000) {
     Serial.println("Short movement");
     shortMov=true;
     Serial.println(shortMov);
    // shortMovement();
   }
   while (shortMov==true){
     shortMovement();
     firstTrigger=true;
   }
  }
}

void shortMovement() {
  for (float i = 0; i < 0.6 * PI; i += PI / 150) {
```

```
//    if (dist() > 40) {
//      // Serial.println("Break");
//      startTime = false;
//      break;
//    }
    Serial.println("Hier");
    value += PI / 20;
    servoPos = int((sin(value) + 1) / 2 * 60 + 60);
    //servoPos = int(map(sin(value), -1, 1, 0, 180));
    Serial.println(servoPos);
    myServo1.write(servoPos);
    delay(10);
  }

  moveTo90(servoPos);
  startTime = false;
  shortMov=false;
}


void moveTo90(int tempServoPos) {

  if (servoPos < 89 && firstTrigger) {
    value += PI / 120;
    servoPos = int((sin(value) + 1) / 2 * 120 + 30);
    myServo1.write(servoPos);
    Serial.println(servoPos);
    delay(10);
  }
  if (servoPos > 91 && firstTrigger ) {
    value -= PI / 120;
    servoPos = int((sin(value) + 1) / 2 * 120 + 30);
    myServo1.write(servoPos);
    Serial.println(servoPos);
    delay(10);
  }
  if (servoPos >= 89 && servoPos <= 91) {
    firstTrigger = false;
  }
}

void servoMovement() {
  for (float i = 0; i < 2 * PI; i += PI / 150) {
    // Serial.println(i);
    if (dist() < 40) {
      // Serial.println("Break");
      break;
    }
    if (dist() > 150) {
      value += PI / 100;
    }
    if (dist() <= 150 && dist() >= 90) {
      value += PI / 60;
    }
    if (dist() < 90) {
      value += PI / 40;
    }

    servoPos = int((sin(value) + 1) / 2 * 120 + 30);
    //servoPos = int(map(sin(value), -1, 1, 0, 180));
    Serial.println(servoPos);
    myServo1.write(servoPos);
    delay(10);
  }

  for (float i = 0; i < 1 * PI; i += PI / 200) {
    //  Serial.println(i);
    if (dist() < 40) {
      // Serial.println("Break");
      break;
    }
    value += PI / 50;
    servoPos = int((sin(value) + 1) / 2 * 120 + 30);
    //servoPos = int(map(sin(value), -1, 1, 0, 180));
    Serial.println(servoPos);
    myServo1.write(servoPos);
    delay(10);
  }


}

int dist() {
  // Clears the trigPin condition
```

```
  digitalWrite(trigPin, LOW);
  delayMicroseconds(2);
  // Sets the trigPin HIGH (ACTIVE) for 10 microsec-
    onds
  digitalWrite(trigPin, HIGH);
  delayMicroseconds(10);
  digitalWrite(trigPin, LOW);
  // Reads the echoPin, returns the sound wave travel
    time in microseconds
  duration = pulseIn(echoPin, HIGH);
  // Calculating the distance
  distance = (duration - 10) * 0.034 / 2; // Speed of
    sound wave divided by 2 (go and back)
  // Displays the distance on the Serial Monitor
  // Serial.print("Distance: ");
  //Serial.println(distance);
  // Serial.println(" ");

  return distance;
}
```