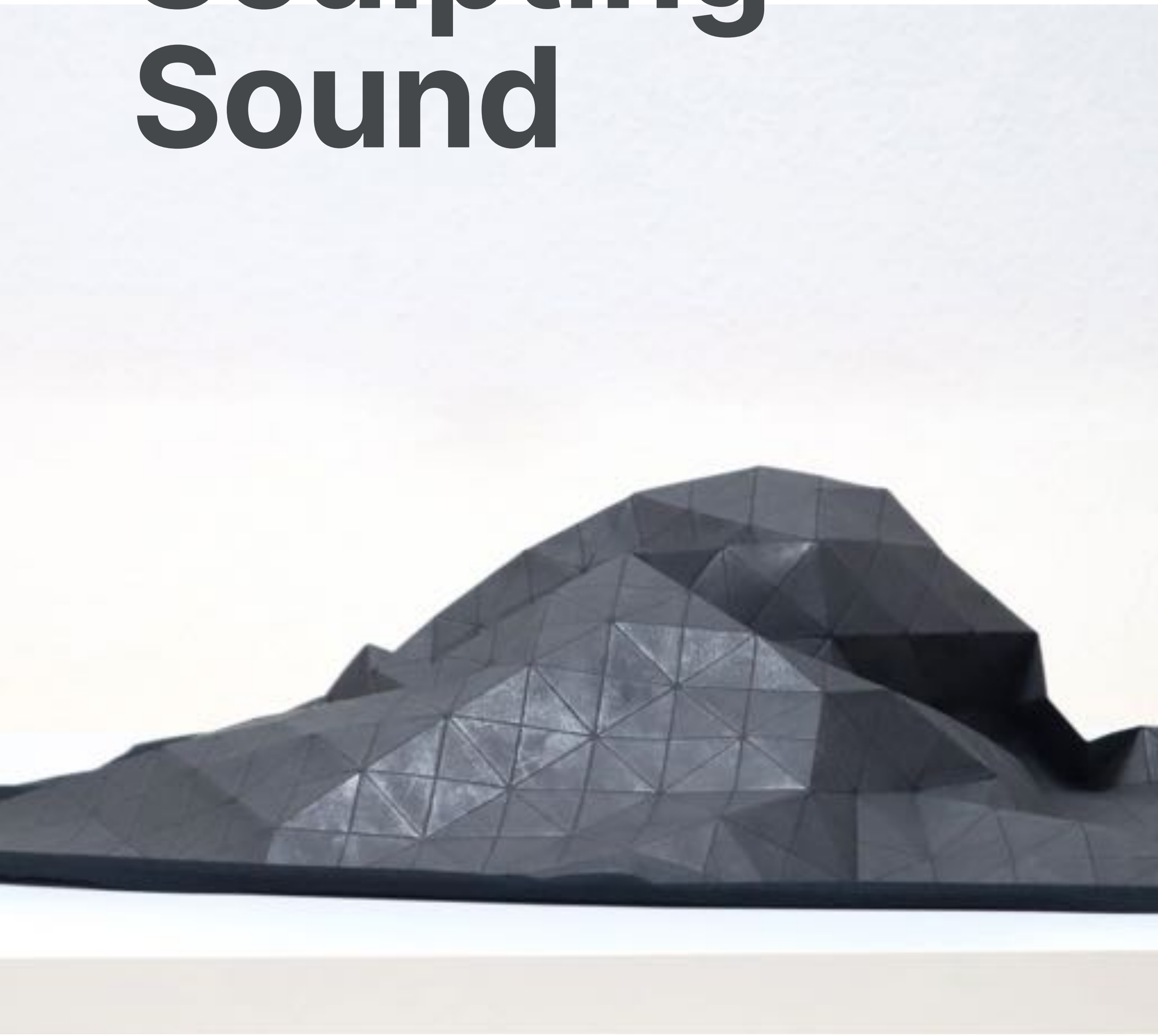
Sculpting Sound



Communicating Bodies
Winter Semester 2021/22
Textile and Surface Design Department
weißensee kunsthochschule berlin

Sculpting Sound
BA project by Lisa Braun
Project supervisor: Prof. Mika Satomi

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Background

This project is conceived and realised within the e-textile course “Communicating Bodies” that took place in the winter semester of 2021/22. The course consists of a series of hands-on workshops that involve the experimentation with soft textile sensors and the application of e-textile design as a means to create a digital language beyond verbal communication.

Concept

If sounds could be shaped, what would they look like?

“Sculpting Sound” is a textile interface project focused on the interaction between shapes, sounds, and movements. Using fabric as a medium, the project explores the possibilities of sculpting sounds through the creation of a mouldable surface that can be shaped, reshaped, and stay in shape.

Inspired by various experiments with conductive materials and the construction of pressure sensors, the project aims to create a structure that not only generates sounds through the changing of shapes, but also has the ability to retain the sounds shaped by the textile landscape.

The basic structure of the interface is formed by a piece of fabric overlaid with two layers of prints. The bottom layer is a geometrical pattern—made out of small right triangles—that strengthens the fabric and allows it to form three-dimensional shapes. The top layer is a graphite coating that, through its conductive nature, functions as a pressure sensor. When being crumpled up, the fabric will transform into a myriad of shapes while simultaneously producing a wide range of sounds.

Through the interplay between opposites—rigid and flexible, soft and hard, silent and audible, material and immaterial—the project facilitates an open and exploratory interaction between shapes and sounds using visible and invisible waves.

Starting Point

During the course, there was a workshop where the class was introduced to a wide range of materials that can be used for building sensors, as well as ways to create sounds using these sensors by means of microcontrollers and code.

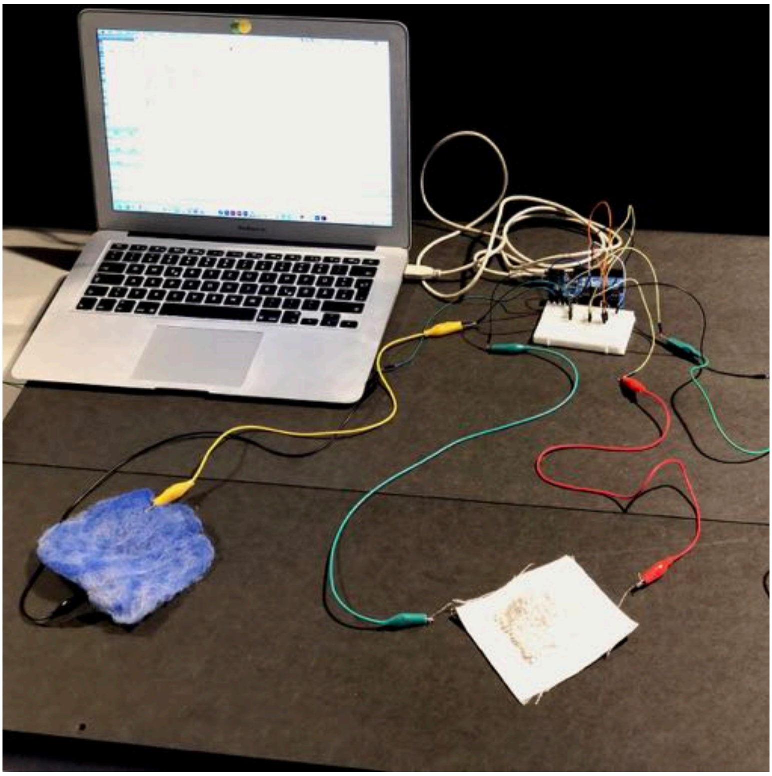
I was working with a piece of felted material composed of a mixture of wool and metallic fibres (hence making it conductive). When pressure is applied to the material, the metallic fibres are being squeezed closer together, which lowers the resistance to the current flow. Through connecting the material to a microcontroller, the change of resistance level can be utilised as a parameter to trigger a sound on the computer.

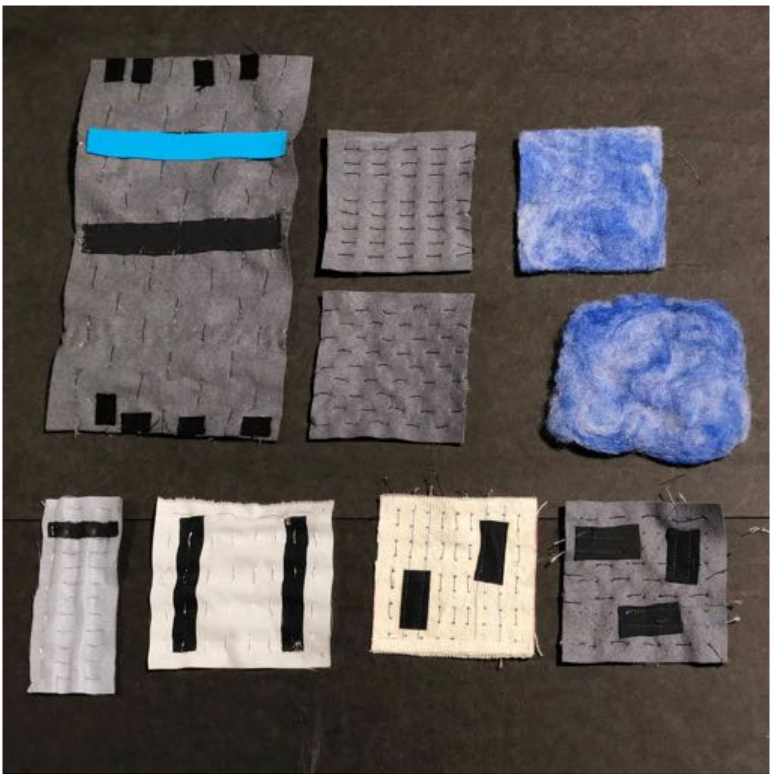
While I enjoyed that the material can produce sounds through compression, I also began to wonder: is it possible to create a surface that can hold its shape and thus retain the sound without any manual intervention? With that in mind, I began prototyping a series of small sensors using wires.

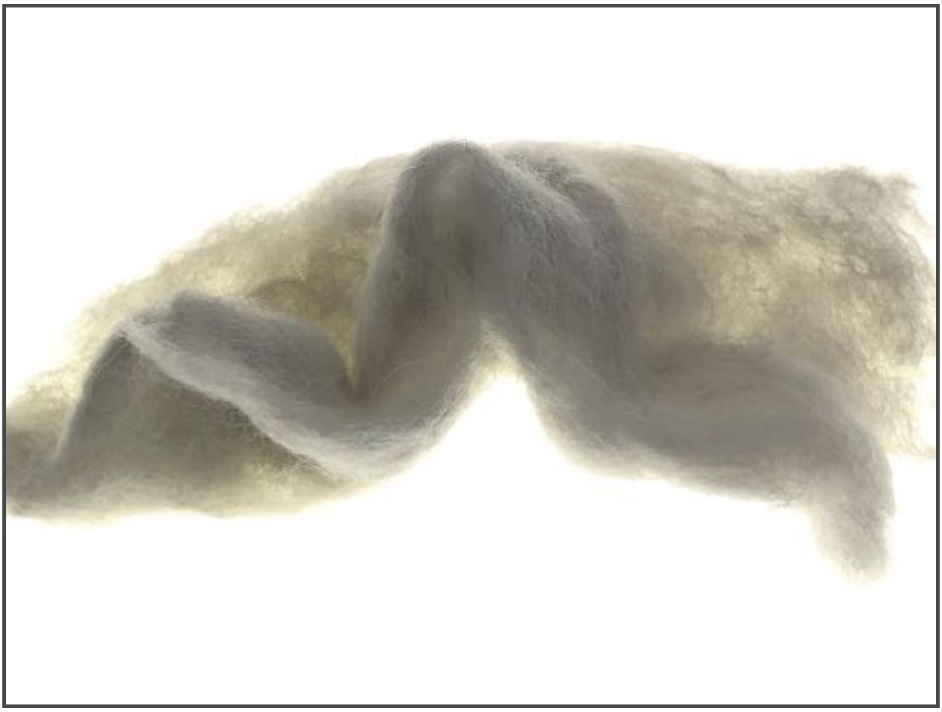
By the end of my experimentation, the sample that stood out was the one constructed with wires wet felted between two layers of metallic wool mixture.

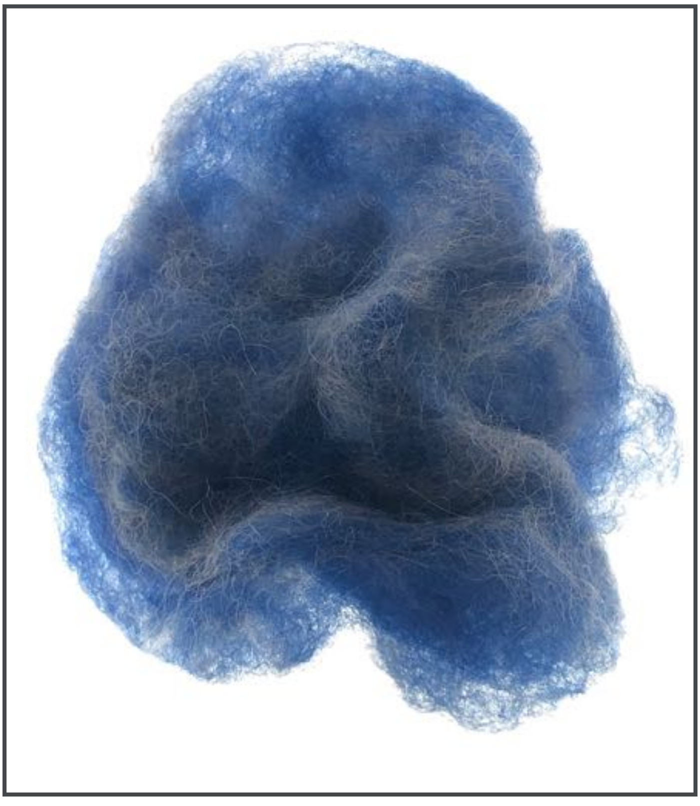
When squeezed, the material forms sculptural shapes that stay in place and therefore can retain the sounds generated. By directly felting the wires in the material instead of inserting afterwards, it also allowed the wires to be concealed. I was particularly in favour of this sample as it was a fun and unique experience to make sounds through forming shapes.

Through this prototyping process, it became clear that the interplay between shapes and sounds is the topic I wanted to explore further in my project.









Previous Iteration

The basic structure of the interface is formed by an embroidered fabric with parallel tucks sewn onto it, creating “pockets” on the surface. Padded wires and sensors (metallic wool mixture) are inserted separately in individual pockets. After connecting to a microcontroller, the sensors can read the pressure level and send signals to generate sounds based on the curvature of the surface. By leaving out specific value indicators, the interactive fabric encourages the audience to engage in the experience of sculpting sounds based on senses and intuition.

While this iteration did succeed in accomplishing the basic functionality of creating sounds through shapes, it also had two major flaws: 1) it cannot be shaped from different sides because the parallel tucks restricted the directions in which the fabric can be pressed, and 2) it lacks the versatility that creates a free-flowing experience due to the accumulated weight of the fabric, wires, and metallic wool mixture. These limitations led me to rethink my design and eventually restart the experimentation process.

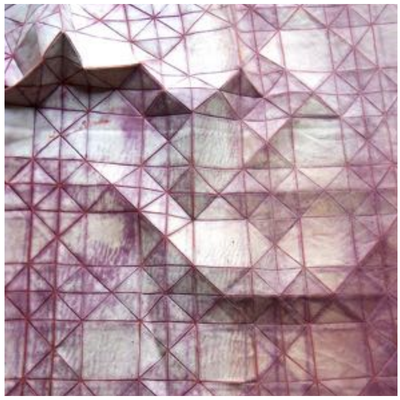
Rethinking the Design

After realising that the initial iteration of my work did not fully translate my inspiration and failed to achieve my goal, I made the decision to take several steps back in the design process and essentially start over from the beginning.

Having evaluated the mistakes I made and analysed the shortcomings of the various earlier prototypes, I eliminated the option of using wires as the basis of my work's structure due to the lack of stability I was aiming for. In the process of researching alternative ways to create a malleable surface that can hold its shape, my advisor suggested Elisa Strotzyk's project Wooden Textiles to me as a reference. From there, I furthered my research in the area of geometrical textile designs, specifically the application of a harder material onto a softer, more flexible surface or fabric.

Project References

Bao Bao bag by Issey Miyake



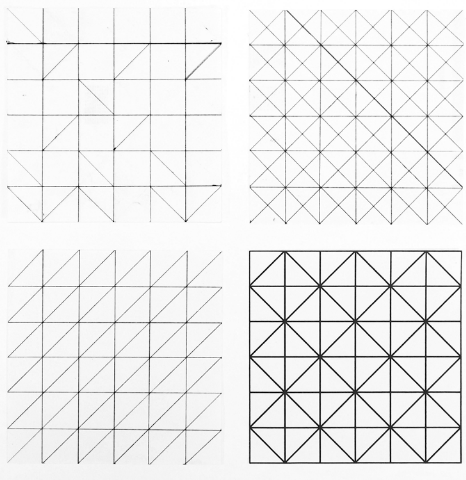
folding-A-part project by Mika Barr

Wooden Textile project by Elisa Strozyk

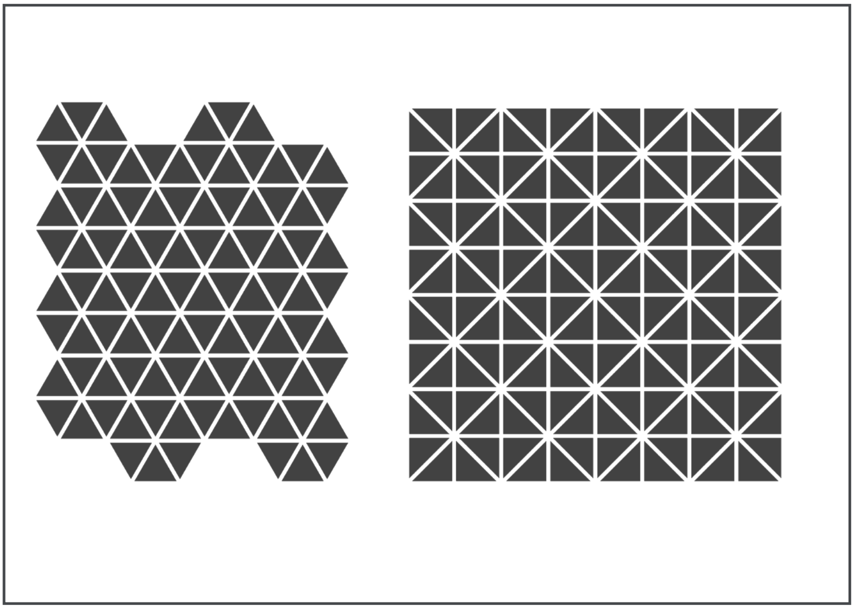
From Draft to Prototype

Having studied a variety of geometrical structures, I began the process of making drafts. To fully understand the constructions, I first started with analogue sketches on paper, then proceeded to digital drawings. As I became more familiar with the shapes, sizes, and proportions, I began looking into different application methods.

After some consideration, it became apparent to me that adding hard materials onto a soft surface is not the ideal approach, as it would cause the fabric to lose its agility and lightness (and hence running the risk of repeating the same mistakes as the previous iteration). With that in mind, I decided to experiment with the technique of screen printing as a means to create a shapeable fabric that meets my key design requirements: keeping the material soft to the touch, and having the structure embedded into the fabric.

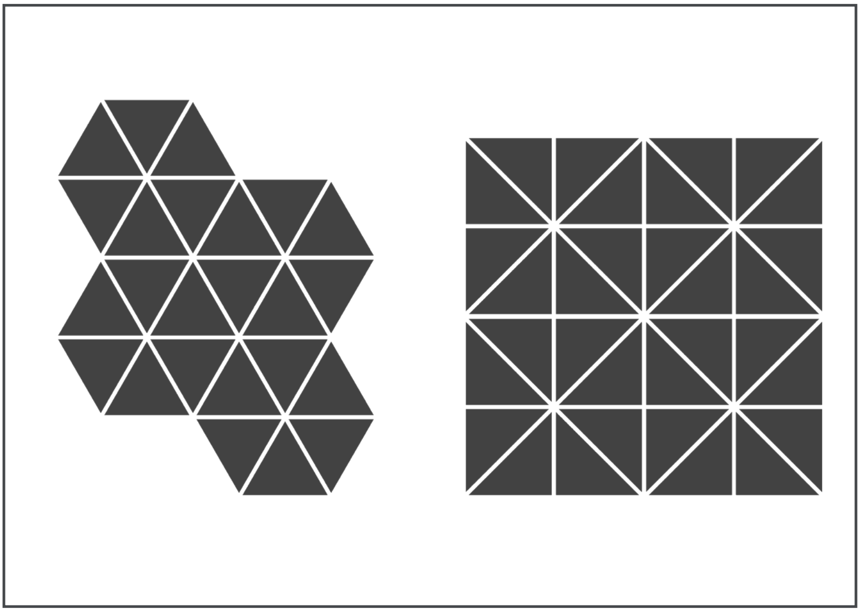


Pattern Sampling



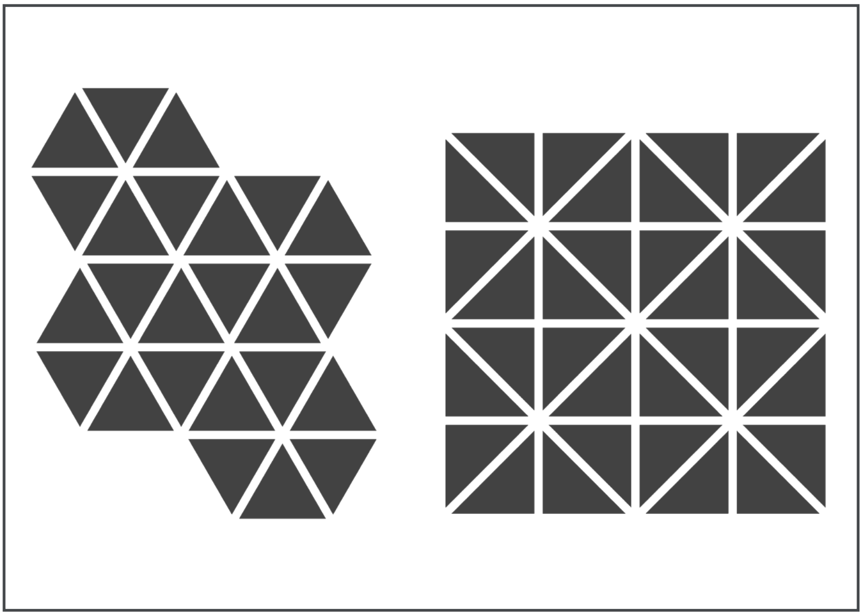
Specifications

Fabric format: A4 (210 × 297 mm)
Length of sides (left): 15 mm
Length of perpendicular sides (right): 15 mm
Distance between elements: 1.5 mm



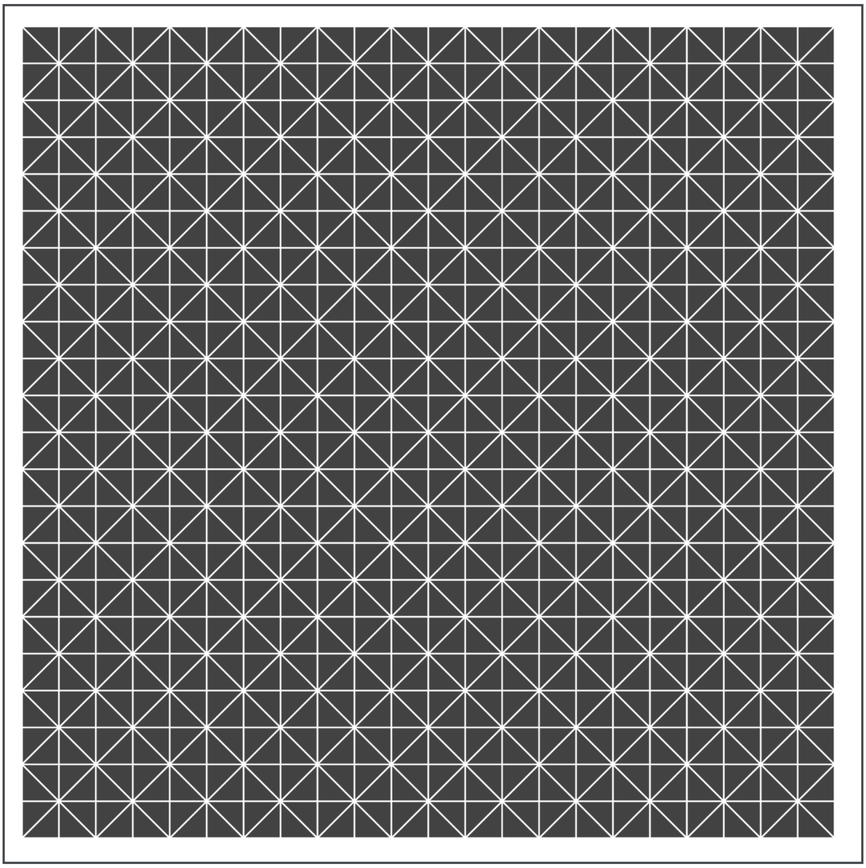
Specifications

Fabric format: A4 (210 × 297 mm)
Length of sides (left): 30 mm
Length of perpendicular sides (right): 30 mm
Distance between elements: 1.5 mm



Specifications

Fabric format: A4 (210 × 297 mm)
Length of sides (left): 30 mm
Length of perpendicular sides (right): 30 mm
Distance between elements: 3 mm



Specifications

Fabric height and width: 75 × 75 cm
Length of perpendicular sides: 3 cm
Distance between elements: 1.5 mm

Sensor Prototyping

Until this point of the project, I have worked exclusively with conductive wool as a sensor, which is why there was an initial learning curve when I had to move away from the material I have familiarised myself with. My advisor, having demonstrated how several layers of pencil marks possess conductive properties, pointed me towards the idea of working with graphite as a conductive element.

The first experiment was conducted with graphite spray. Although the spray does work on textiles, it is not particularly suited for applying on an extensive surface as the application method is quite concentrated, resulting in patchy areas that have uneven amounts of graphite particles.

Following that, micro graphite powder was tested in the screen printing workshop. The powder—used as a pigment—was mixed with a binder to be applied as a coating on the fabric. Two different kinds of binders were also tested. While they both managed to print a layer of graphite on the fabric, one of them showed some signs of cracking after it was dried, so I opted for the other one (Printperfekt).

Specifications

Binder: Printperfekt base
Screen-printing mesh size: 43T
Graphite powder grain size: micro

Testing parameters

Conductivity
Flexibility
Heat resistance

Fabric Selection & Print Test

Fabric samples

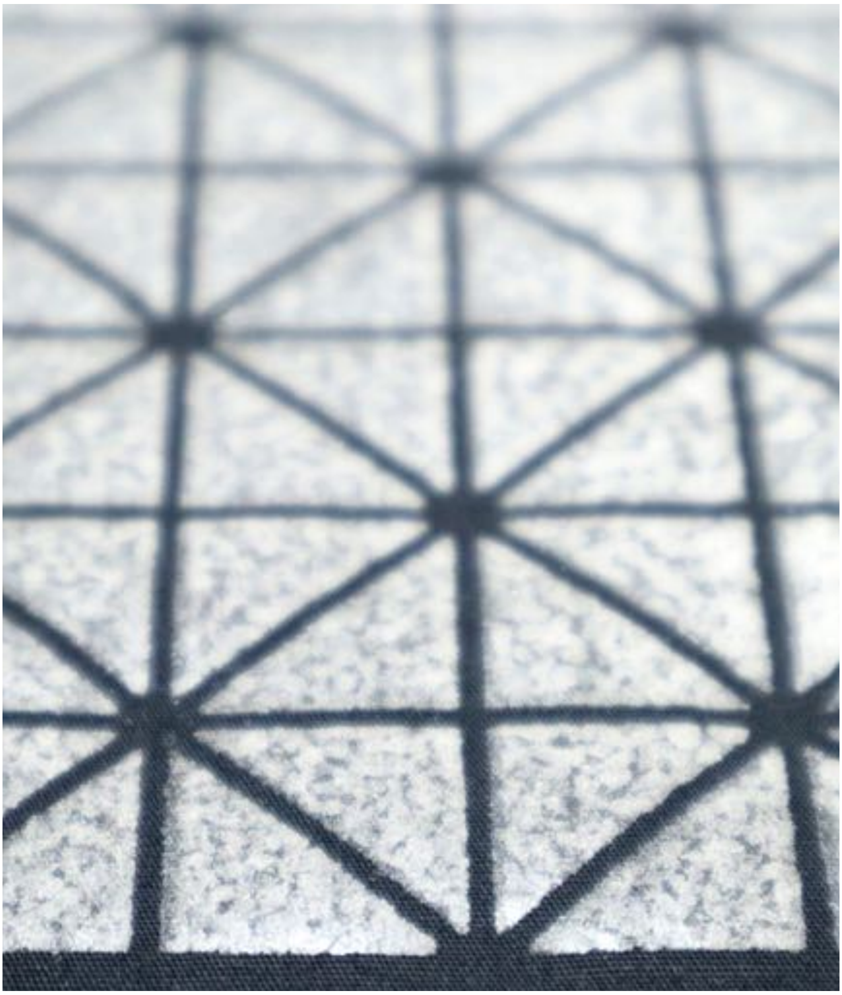
100% cotton (2 weights)
98% cotton; 2% elastane
68% viscose; 32% polyester
60% cotton; 20% polyester; 20% polyurethane
90% viscose; 10% metal

Specifications

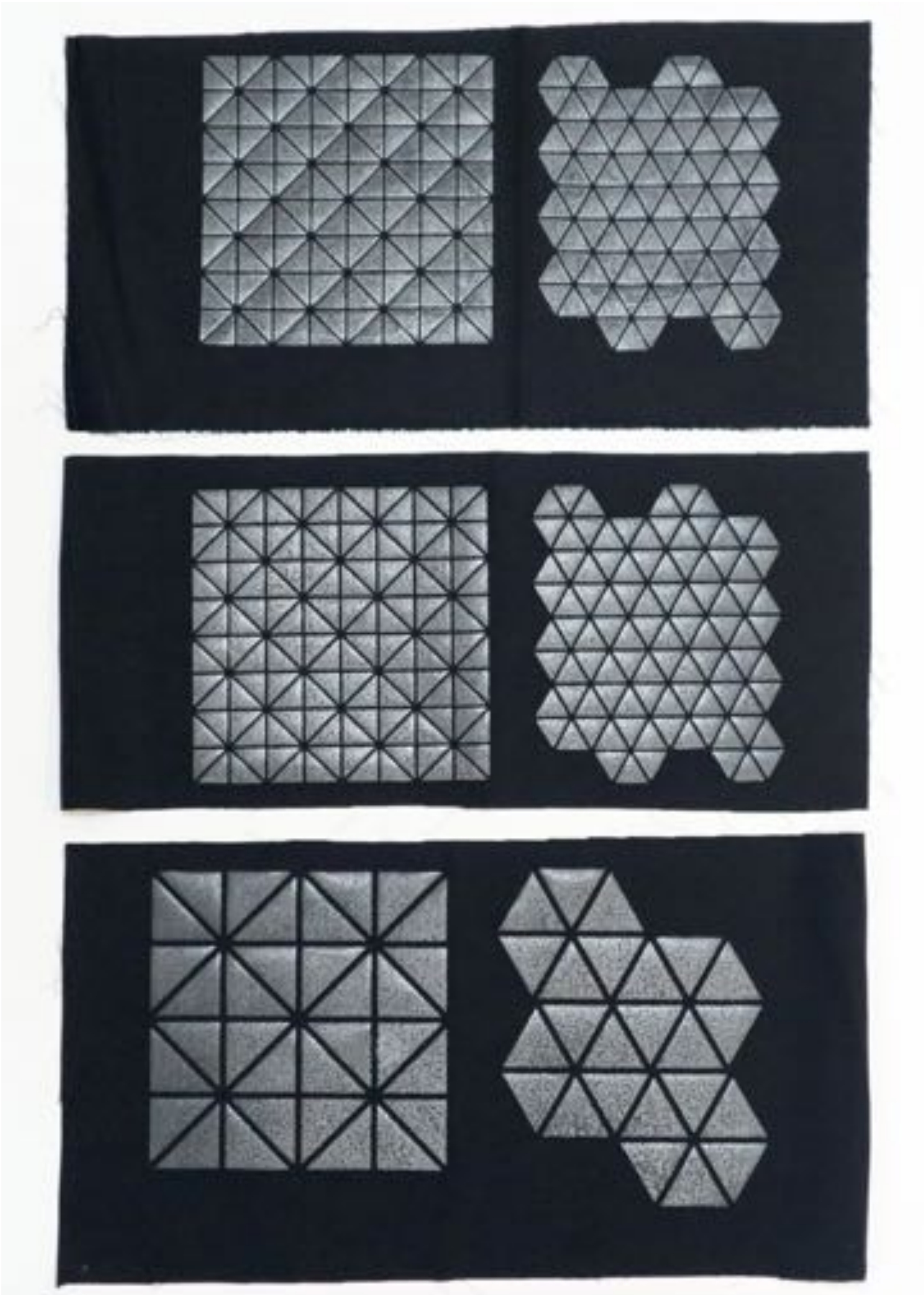
Fabric composition: 100% cotton
Printing layers: Acrodur 950L x 3
Heating temperature & time: 190°C for 60 seconds

After the experimentation process, fabric made out of 100% cotton proves to work best for the purpose of this work.

Fabric Selection & Structure Test



Structural layer screen printed with water-based acrylic binder Acrodur on the fabric.



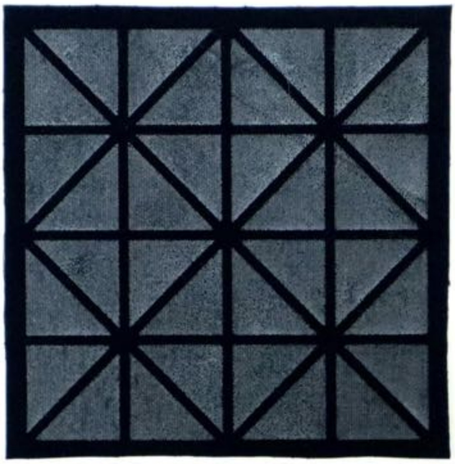
Prototyping & Sampling

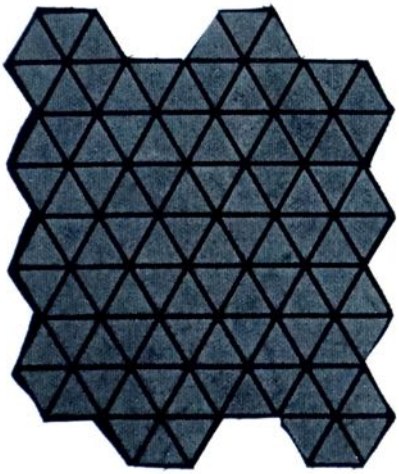
After testing the printing of the geometrical structure and the conductive layer, the results were combined for further testing and prototyping. Two placements were tested for the application of the graphite paint: 1) on top of the structural layer, and 2) on the bottom side of the fabric.

The geometrical structure of the work is printed with Acrodur—a water-based acrylic binder that gets activated and stiffens when heat is applied to the dried printed layer. As I was planning to connect my structural print with the conductive layer in the following steps, I made it a priority to test out the graphite paint's ability to withstand high temperatures. In some instances, conductive materials such as graphite lose or significantly reduce their ability to conduct electricity when heat is applied. Depending on the sequence of printing and the number of layers required, there could be a chance that the graphite paint would have to withstand high temperatures.

Flexibility, conductivity, heat resistance, and aesthetics were the factors taken into consideration. After conducting extensive tests with different combinations of variables (shapes, sizes, layering sequence, structural details, etc.), it was concluded that printing the graphite layer on top of the structural layer was the optimal option. The printed fabric remained flexible and the layers of prints did not show signs of cracking or breakage when pressure is applied or movement is involved. When graphite paint was applied on the bottom side of the fabric, the end result was more rigid, thus limiting the range of possible movements.

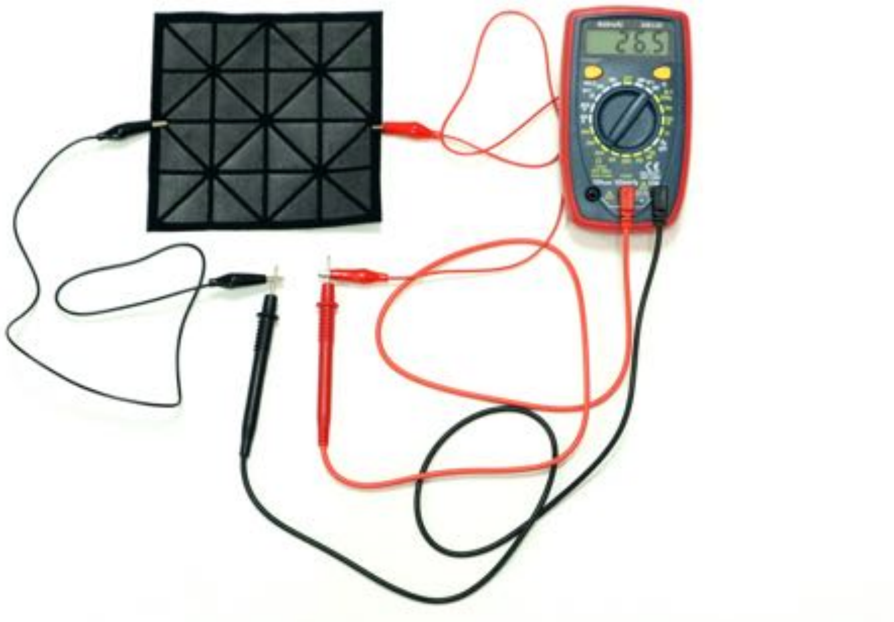
While working on prototyping and sampling, I was pleasantly surprised by the aesthetics of the graphite paint. An interesting quality I have observed about the painted fabric was that the more it is touched, the shinier it becomes. This unique attribute of graphite lends itself to my project as it can “record” and reflect the interaction that people have with the work over time through its changing appearance.





Graphite Paint Conductivity Test

To test out the resistance of my fabric, some preliminary tests were conducted by attaching clamps to the edges and measuring the resistance across the whole fabric.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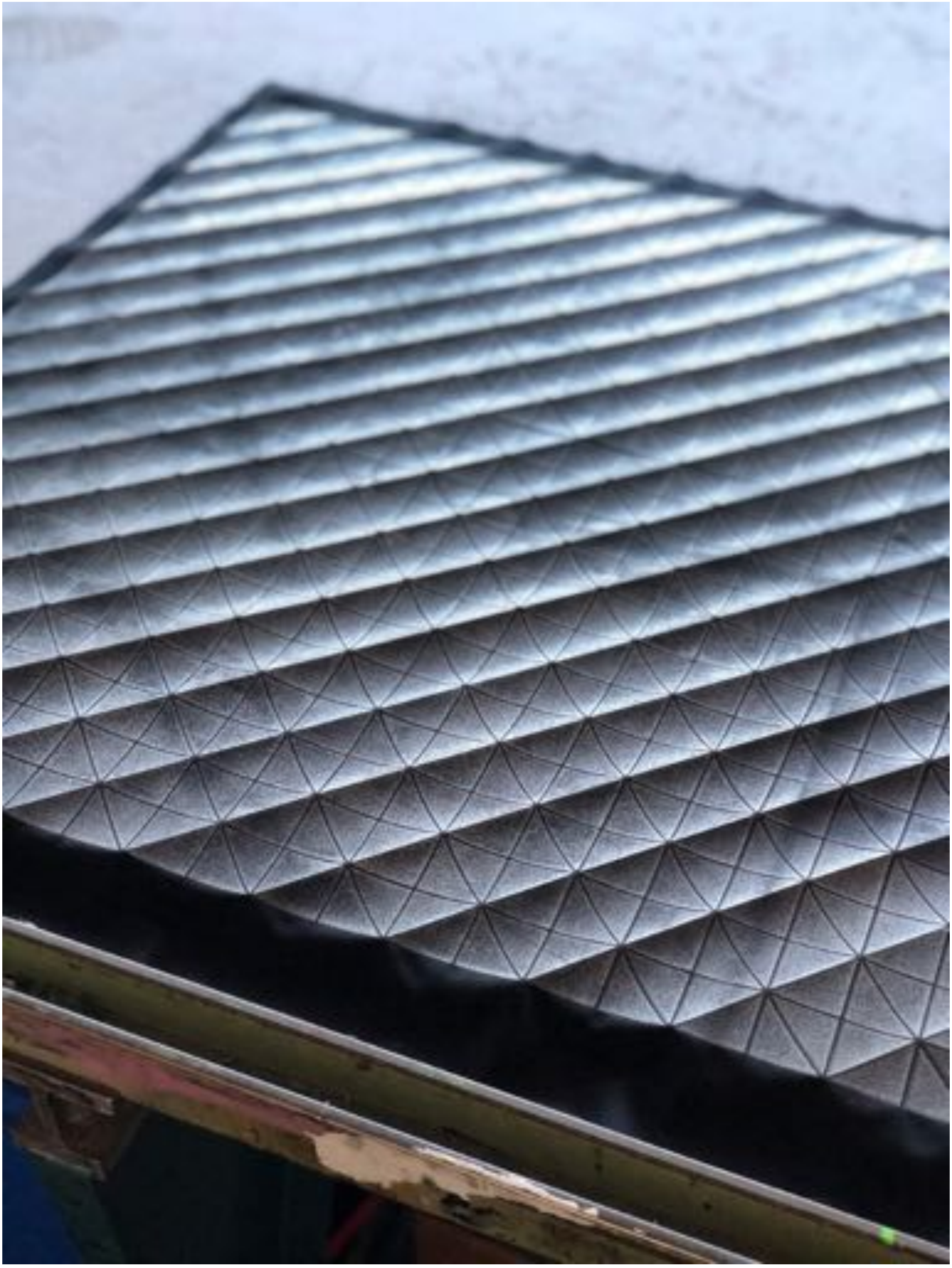
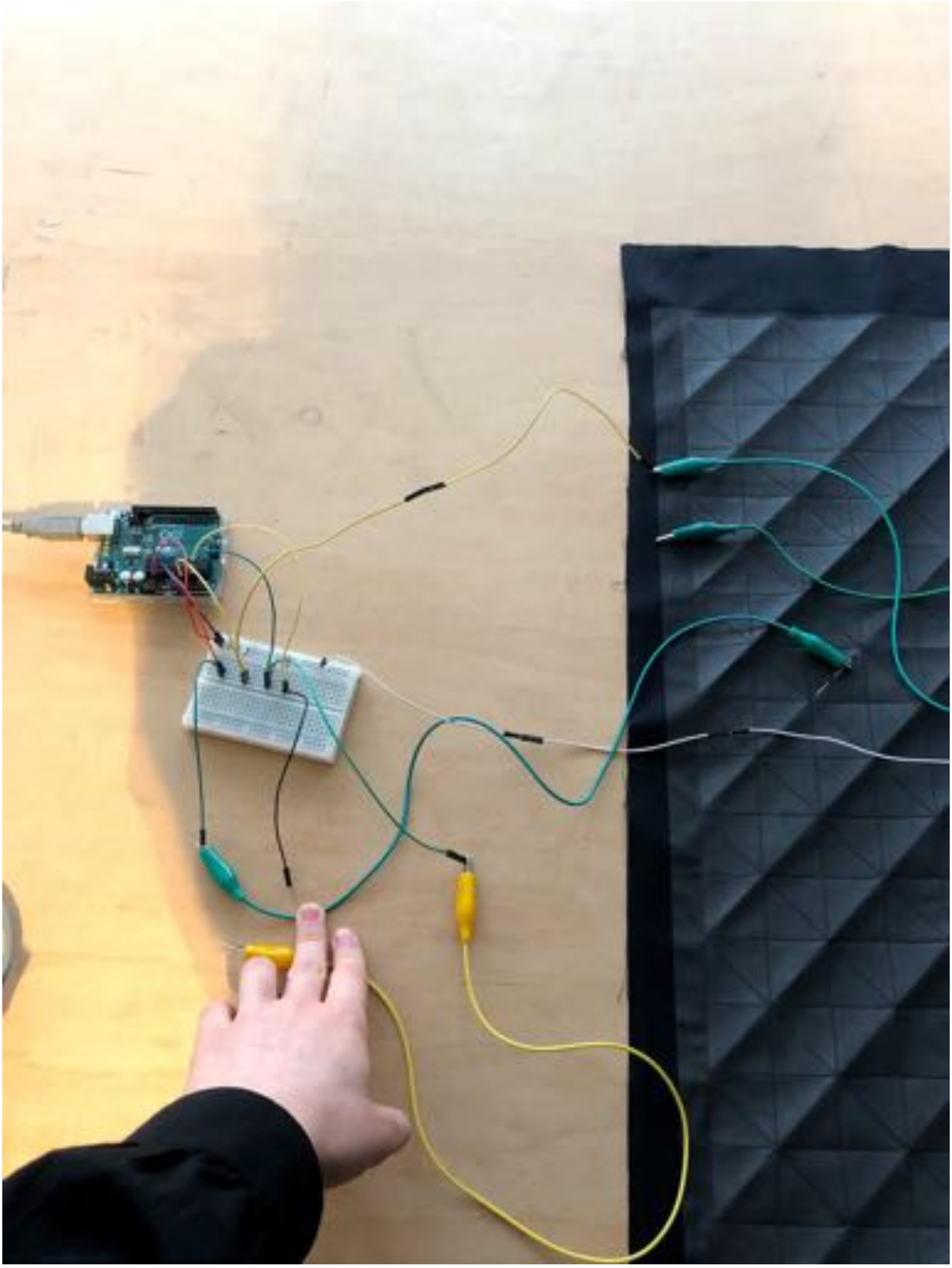
Printing Process



Mapping Out Surfaces

To establish a connection between the fabric and the microcontroller for experimentation, pins were inserted into different points across the surface of the fabric. Using crocodile clips, these pins were attached to jumper cables, which were plugged into a breadboard and connected to the computer through a microcontroller. On the computer, different sounds were assigned to different areas of the fabric using the audio programming language Pure Data (PD).



Sewing Test

In an attempt to make more permanent connections, conductive threads were sewn in the areas that were previously mapped out. These connections, however, did not work the way it was expected. These sewn-in connections were too high in resistance and they failed to provide any reliable readings. Even after multiple adjustments and numerous attempts to rectify the problem, it was difficult to get consistent, usable readings for the design to function properly.

Due to time constraints and limited capacity, I decided against further investigating this issue for the time being and instead seek out a more stable connection method.

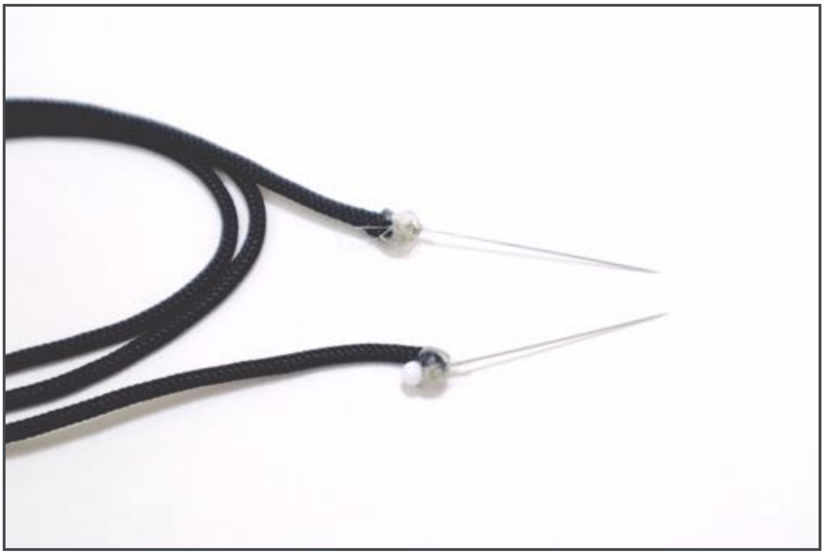
Testing threads

Imbue; Elitex Stickgarn
Karl Grimm; High Flex Silver (solderable)
Madeira; polyamide; silver-plated

Sewing areas

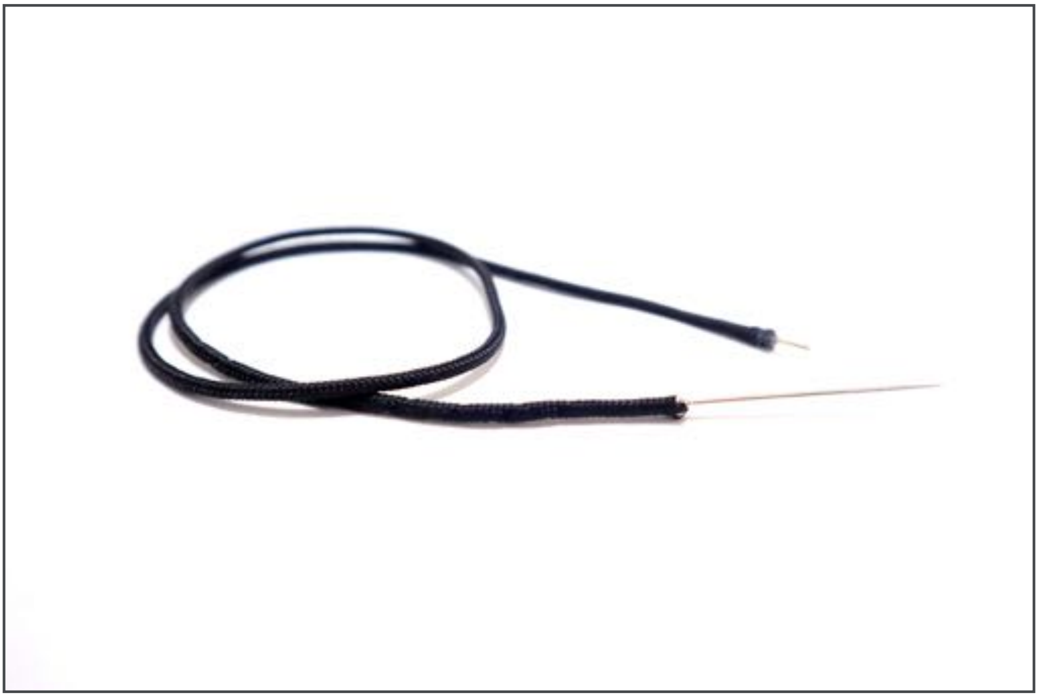
Diagonal lines
Intersection point of triangles
Straight lines

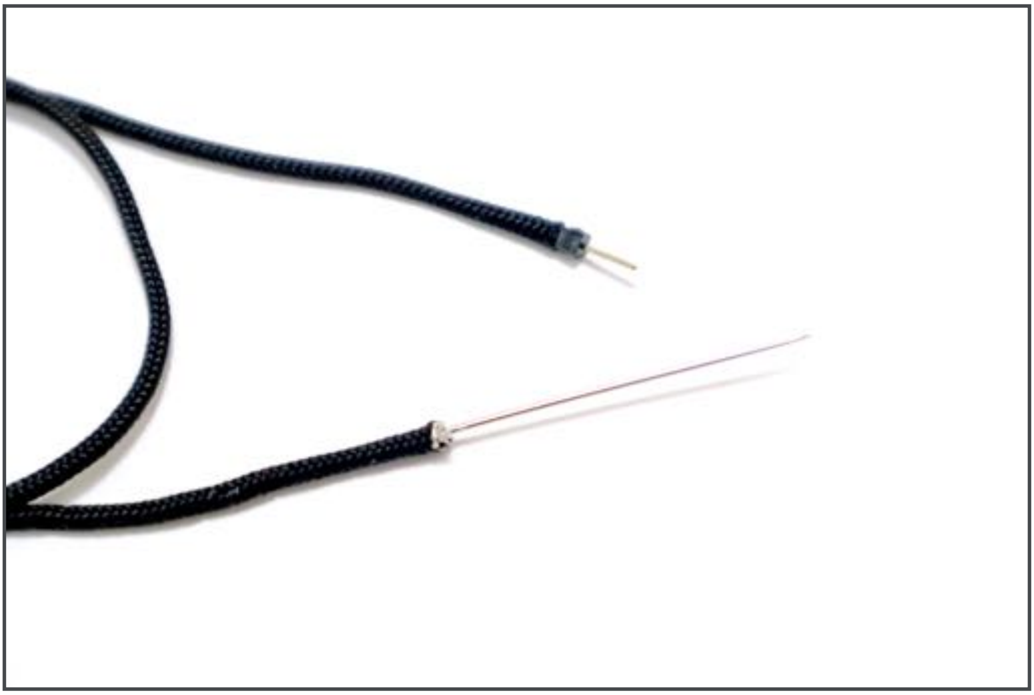
Cable Prototyping



As an alternative to permanent connections, I opted for improving the original pin connections. To replace the crocodile clips, textile cables were designed and custom-built to connect the fabric to the breadboard. Each textile cable is made out of a paracord with a conductive thread passing through, attached to a needle on one side and a pin on the other. The conductive thread serves as the connector, whereas the paracord insulates the thread and prevents false readings caused by short-circuiting. In the earlier prototypes, the pin was attached to the thread using methods such as glueing and tying. In later iterations, I improved the construction of the cable by soldering the pin directly to the thread, allowing it to be directly plugged into the breadboard.

The advantage of this connection method is that it is flexible in terms of the number of sensors to be used and their positions on the fabric. The adjustable nature of these connectors makes room for exploration of parameters, as well as making the work more modular and customisable.

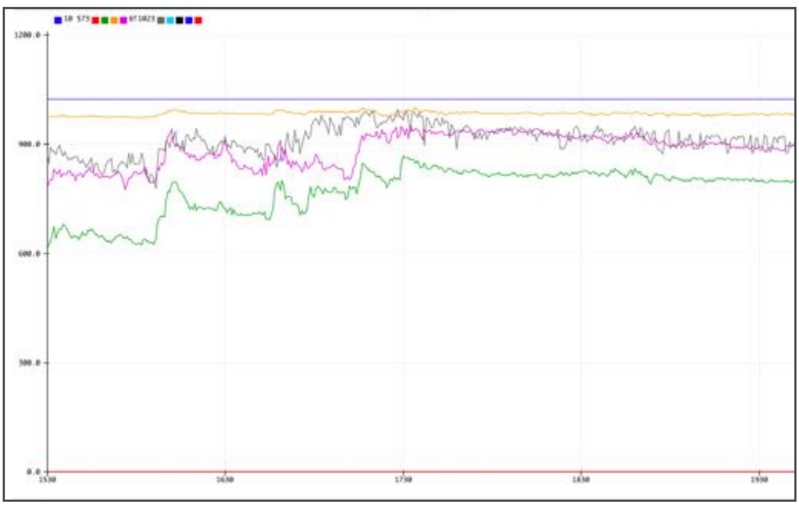




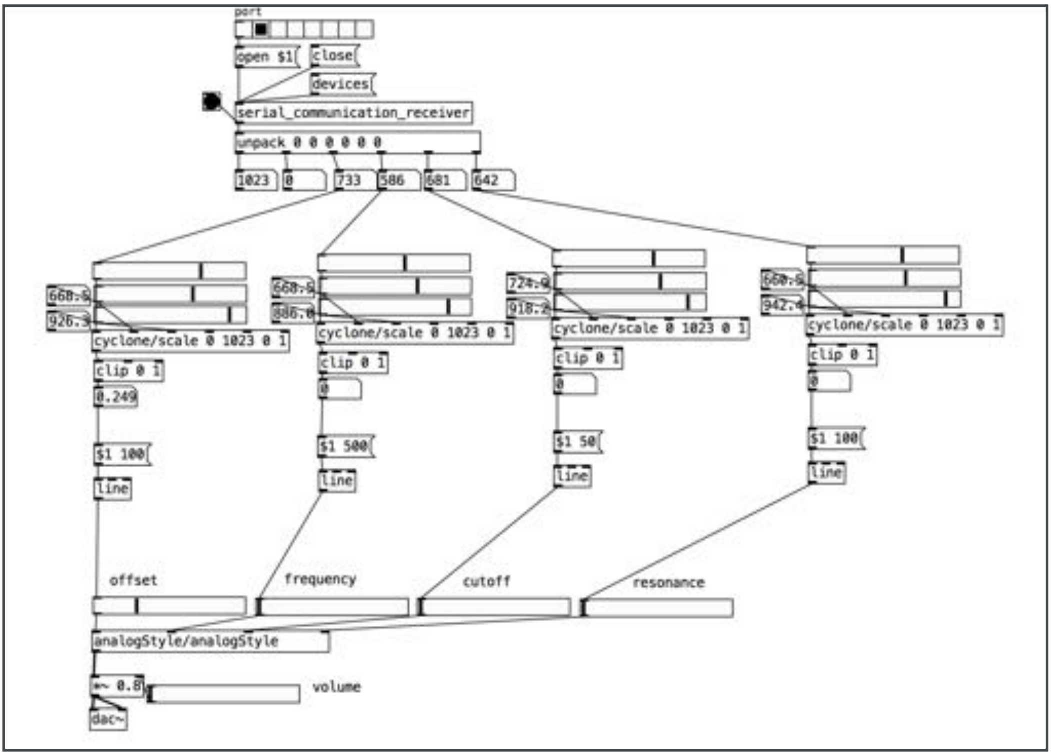
Arduino & Pure Data Codes

```
Serial_read_simplified
void setup() {
  // initialize serial communication at 9600 bits per second:
  Serial.begin(9600);
}

void loop() {
  // read the input on analog pin 0:
  int sensorValue = analogRead(A0);
  int sensorValue1 = analogRead(A1);
  int sensorValue2 = analogRead(A2);
  int sensorValue3 = analogRead(A3);

 // print out the value you read:
 Serial.print(1023);
Serial.print(" ");
Serial.print(0);
Serial.print(" ");
Serial.print(sensorValue);
Serial.print(" ");
Serial.print(sensorValue1);
Serial.print(" ");
Serial.print(sensorValue2);
Serial.print(" ");
Serial.print(sensorValue3);
Serial.println();

 delay(1);        // delay in between reads for stability
}
```

Sensor readings as represented in the Arduino programme.



Plotter showing sensor reading as graphs.



Example of Pure Data file.

Final Outcome

The final outcome of my project consists of two large-scale conductive fabrics that function as an interface to create sounds through shapes. Each fabric is screen-printed with two layers of coating: the first layer (a water-based acrylic binder) provides the geometrical structure and supporting framework, whereas the second layer (graphite mix) functions as the conductive medium. Between the two fabrics, one is trimmed closely at the edges, where the geometrical print ends. The other one contains a thin border (approx. 1.5 cm) of unprinted fabric around the printed area, which gives the piece slightly more grip on the surface it is being placed on.

Customised connectors are also designed and built for attaching the fabrics to a microcontroller. Each connector consists of a soldered pin on one end and a needle on the other, linked together using a conductive thread that passes through a paracord for insulation. Connections can be established between the fabric and the microcontroller by attaching the needles to the unprinted side of the fabric and plugging the pins into a breadboard. When connected, pressure on the surface can be detected and measured through the changing levels of resistance, thus allowing it to generate a range of sounds corresponding to its varying shapes.


Outlook

Looking at the current outcome, I am pleased to see that the work manages to fulfil its intended functionality while simultaneously translating the initial inspiration and meeting the expectations of how it should look and feel. The work preserves the same element of surprise, and the interplay between shapes and sounds arouses curiosity and fascination.

In future iterations, responsiveness and connectivity are the two main areas that can be improved. To understand what adjustments can be made, further investigation into the behaviour of the sensors and connectors needs to be conducted.

On a structural level, it would be interesting to further explore the possibilities beyond regular and symmetrical geometrical structures. In the present stage, the design is made up of regular shapes that are evenly distributed, but there could be possibilities to create an alternative version of the work using irregular polygonal shapes. Another aspect that can be explored is the size and scale of the work. It would be intriguing to see this technique applied to much larger surfaces in different contexts and scenarios.

A noteworthy comment I received during my project presentation was that my work, when rolled up, resembles fabrics that are produced in large quantities and can be bought by the metre in a shop. If that would be the case, this work could potentially take up the role of being a material itself and be used by other creators to build their own interfaces and projects.
As someone passionate about materials and material culture, I find this possibility particularly exciting. That said, the outcome of this project can be expanded in multiple directions, from product and material to more performative applications

Acknowledgements

I would like to take this opportunity to sincerely thank my supervisor, Prof. Mika Satomi, for providing me with constructive feedback, helpful advice, and guidance throughout this project. This work would not have been possible without her kind mentorship, patience, and continuous encouragement.

A very special thank you to the screen printing workshop manager, Louise Drubigny, and the stitching workshop manager, Kathrin Jahnes, for sharing their extensive knowledge and experience with me during the prototyping process. Their generous assistance made all the difference.

Many thanks to all my peers and the students from Spiel und Objekt Masters at Hochschule für Schauspielkunst Ernst Busch for their contribution to an inspiring learning environment. Thank you to Prof. Hannah Perner-Wilson for co-organising and facilitating the workshops. I would also like to extend my gratitude to the guest speakers for sharing their work with us.

I also wish to express my appreciation to all the staff at weissensee kunsthochschule berlin for making it possible to work on campus again.

Last but not least, I would like to thank my family, partner, and friends for being supportive and encouraging throughout this project.

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