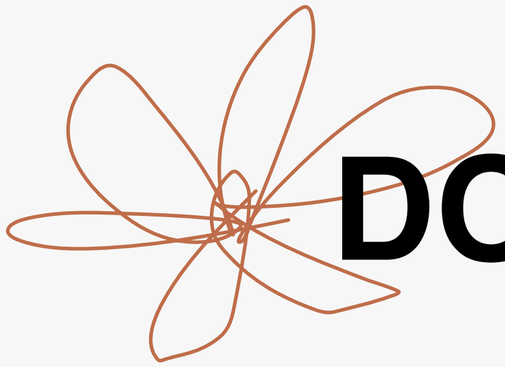
David Wollschlegel, Lydia Frei, Alec Nikolov





# DOCUMENTATION

Instructors: Dr. Joëlle Bitton, Verena Ziegler, Aurelian Ammon

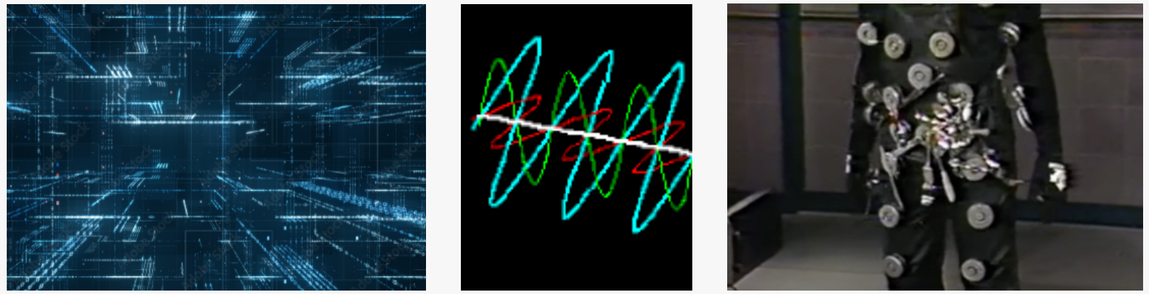
# CONTENT

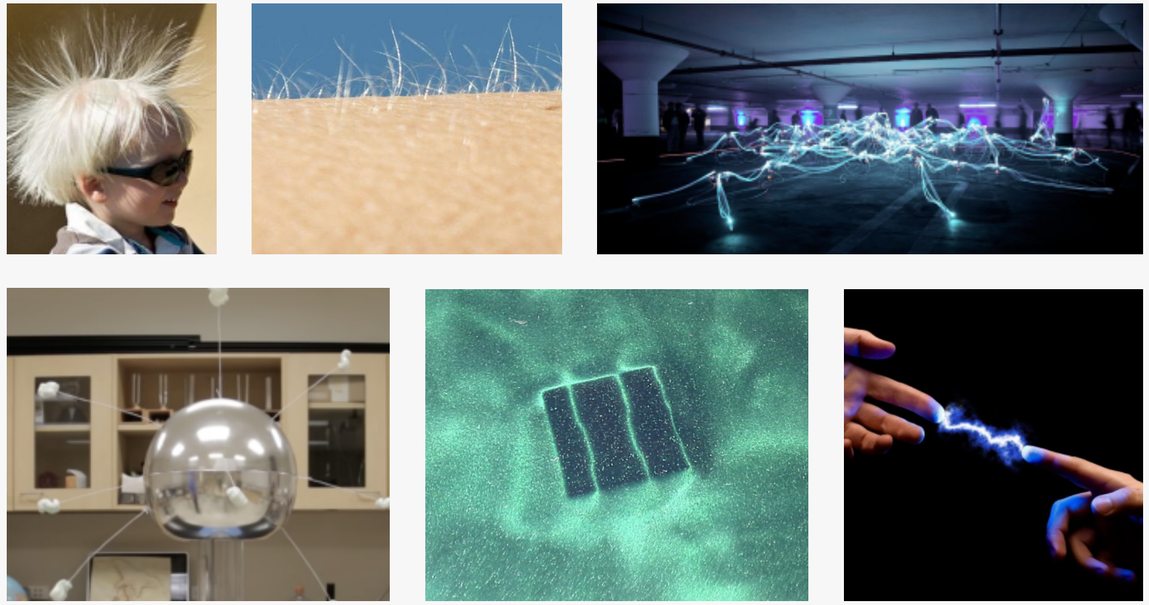
# IDEATION

# 01 RESEARCH

To start and guide our project in one direction we brainstormed and collected content and inspiring projects for the three different approaches [1] Material/ Shape/ Aesthetics, [2] Function, and [3] Speculative. We are interested in electromagnetic waves, data that are not visible and tangible to us, charge and attraction. In addition, we find the interaction and the exchange between two people very interesting. We than descided to look closer at the topic static charge. One of our intentions, which accompanied us through the project, was to stimulate the body and, as a result, make the hair stand up or simulate it.

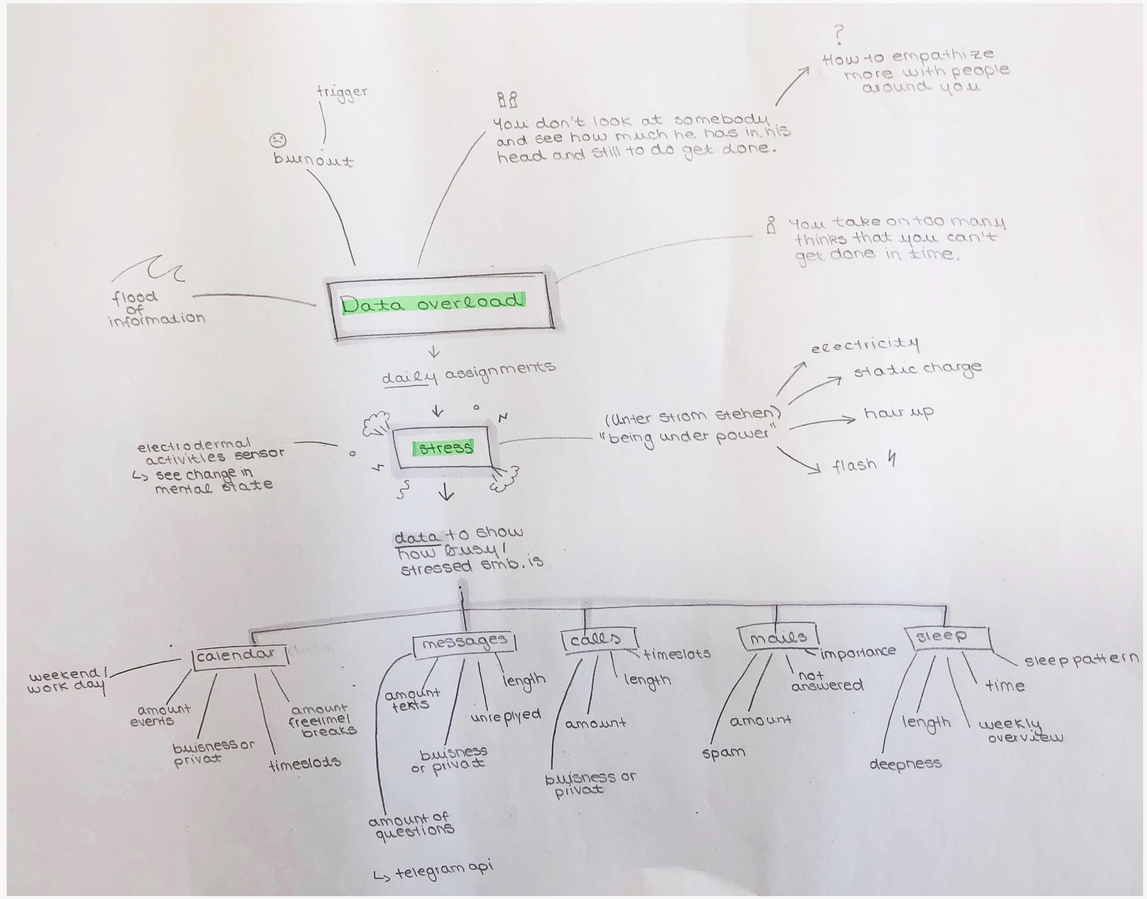
inspiration





# 02 CONCRETIZATION

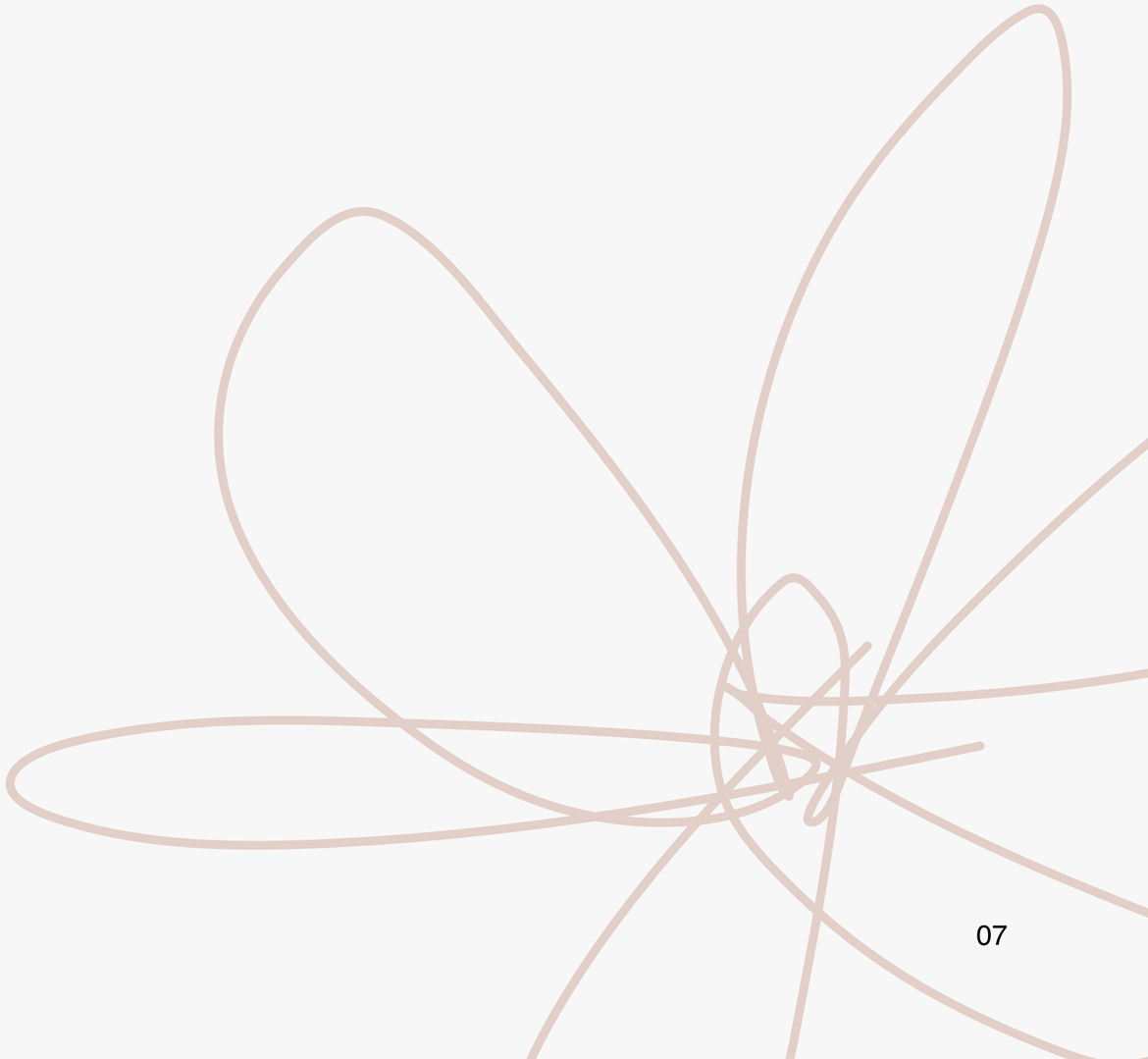
Humans are facing a growing flood of information driven by an overload of technology, that does not seem to stop increasing. So we ask us how can we make the individual digital load or stresslevel and pressure more tangible by embodying data. By detected overload, one could be charged by a voltage, which can be visualisied in an electrified state of the fabric. Furthermore, the electric charge can cause shocks when touching metallic surfaces, which are usually to be find in electric devices. But it also deloads itself by touching other people. So there's the possibility to build on top of this notion and integrate those effects in our concept.

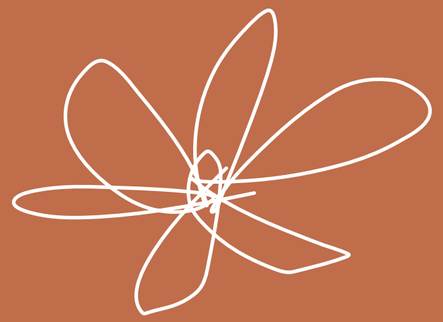


# CONCEPT

# 01 CONCEPT

Humans are more and more flooded with information in their everyday life. In a world full of smart devices we are constantly surrounded by data exchange and evaluation. This sets one under tension. “Unter Strom stehen” is a german expression for being tense. It is difficult to become aware of these quantities and to escape from them to take a timeout. Our wearable deals with that overflow of information by bringing you back into the moment. With electrostatic charge we want to visualize this tension and through the interaction with others one can discharge – finding back into the moment.



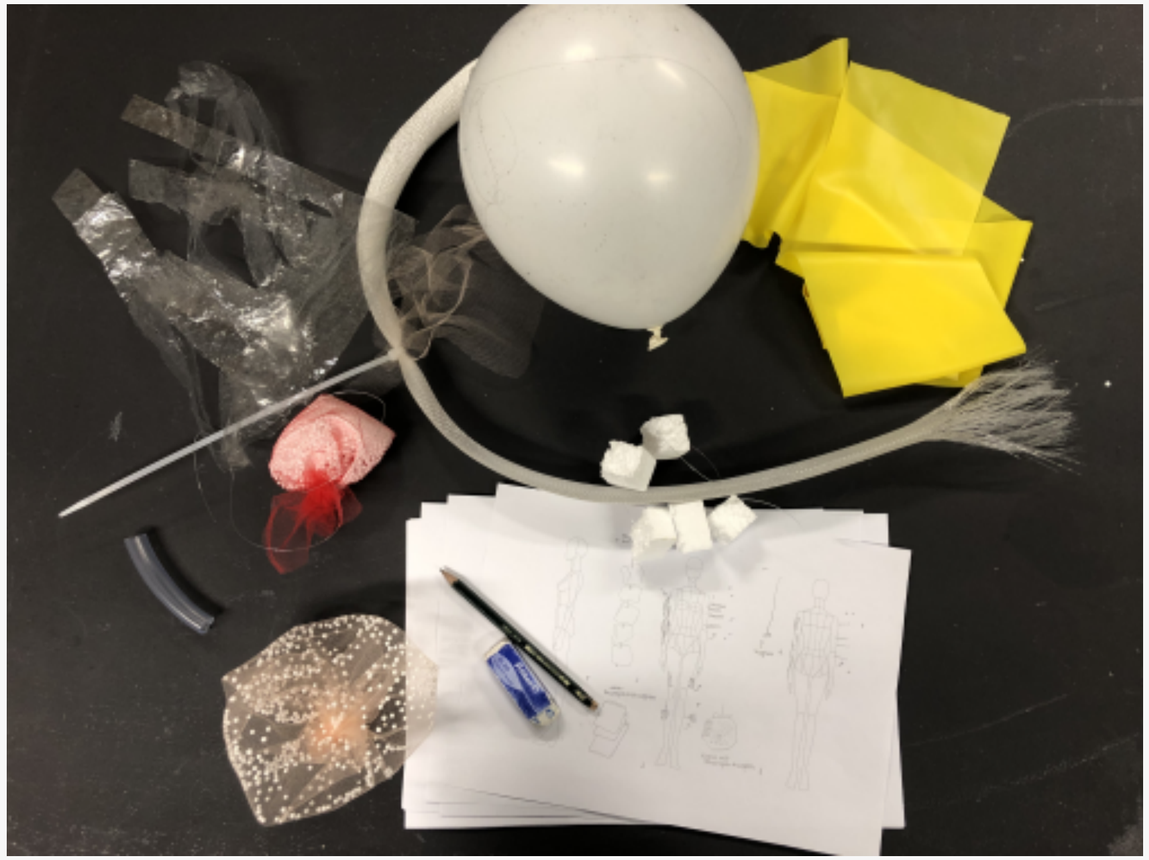


# “UNTER STROM STEHEN”

Meanings: [1] Electricity: having current flowing through it.
[2] Psychology: transmitted by mental or physical stress,
being tense, under strain.

# 03 APPROACH

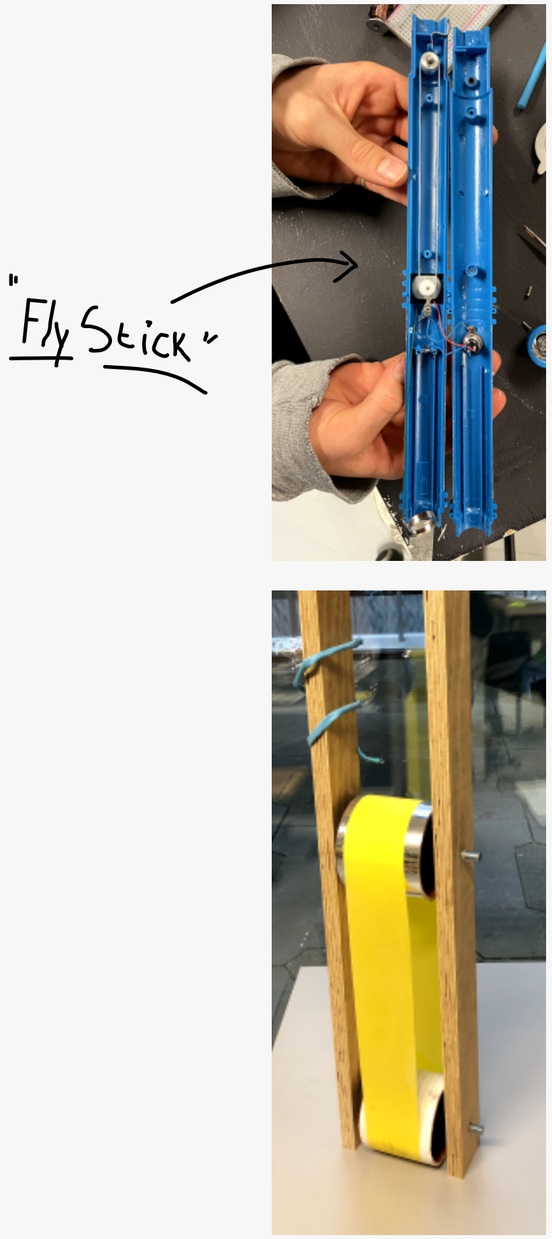
To achieve our goal, we approached the project in a very experimental way. We tried out lots of different material combinations until we found the best one. Our process is structured in small little experiments which guides us through the module. A lot of findings came up during those experiments.

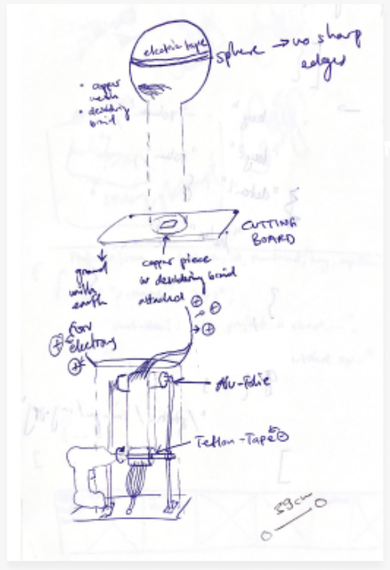


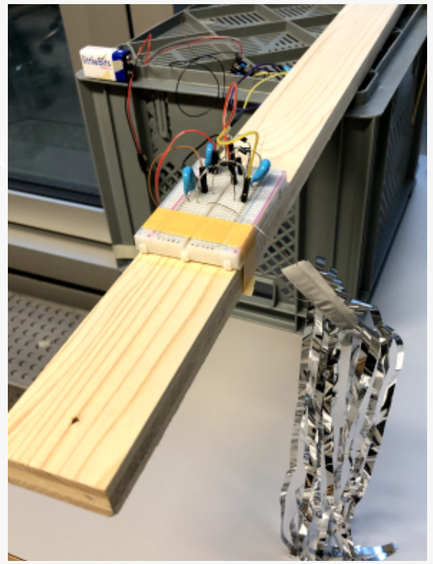
# EXPERIMENTS

# 01 GENERATION

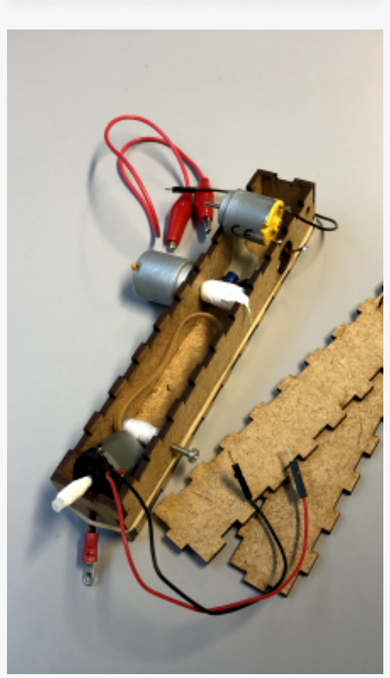
We have tried different ways to generate the electric charge the easiest, fastest and strongest. We started with simple friction. A Van de Graaff generator, also called a ribbon generator, is an apparatus for generating high DC electrical voltages. It is one of the electrical generators and converts mechanical energy into electrical energy, but with very low efficiency. The plan was to build our own.We have built a large as well as a small one. Unfortunately, both did not produce the desired effect and were too weak. Because of that, we also looked into something with fewer mechanical parts. We ordered an air purifier ionizer, which ionizes the air. Because it has less voltage than the generator, we tried to increase it with a voltage multiplier circuit. It worked, but the electrostatic charge needed much more time to build up and it was also not as strong as the one from the generator. The so-called "Fly Stick" we ordered, which includes a small Van de Graaff generator, mechanics worked best. We descided to integrate this into our wearable and work with it later on.

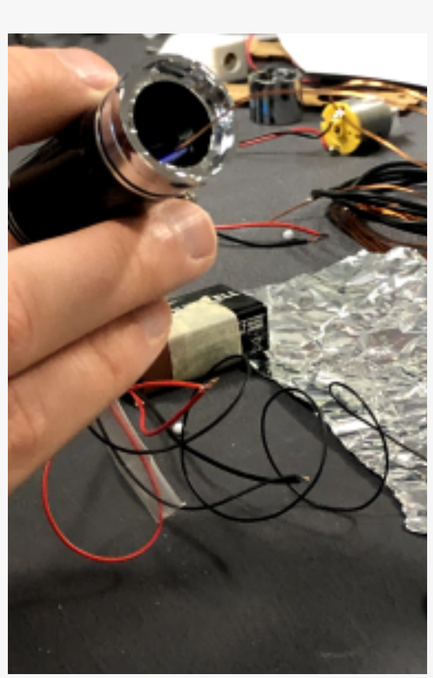






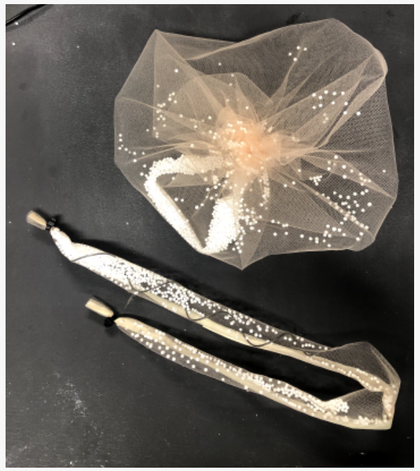
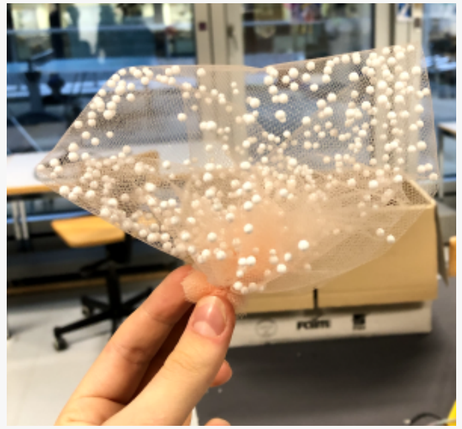


# 02 MATERIAL

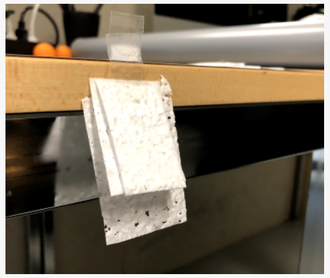
Meanwhile, we started experimenting with different materials. We tested how which materials react to the electric charge. The first thing that came to mind was styrofoam. We tested it in different shapes like beads, scales or even in bigger pieces. The small balls in the tulle ball promised the best effect.

Styrofoam



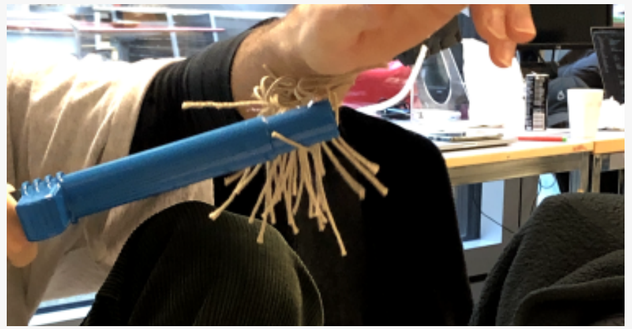



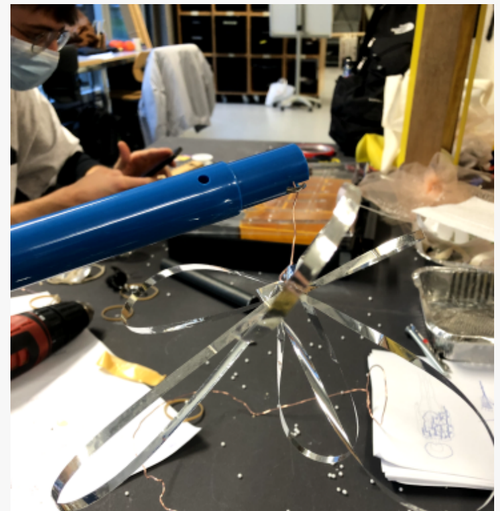


# 02 MATERIAL

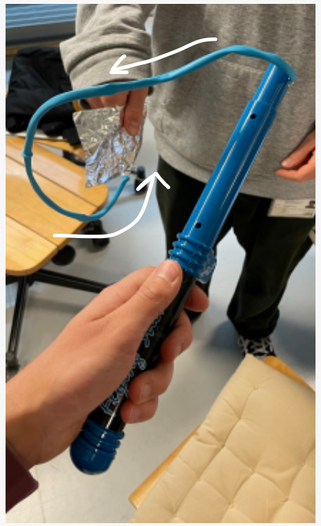
wool →

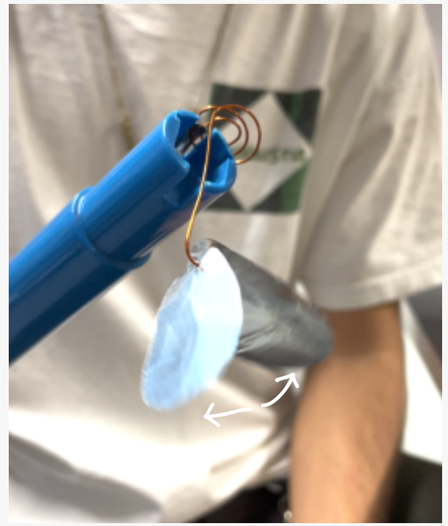




wire mesh →

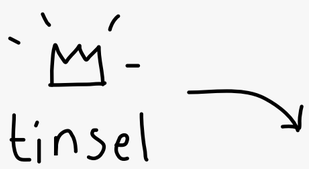
Aluminium →

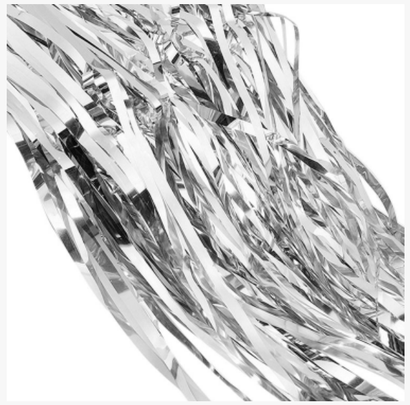


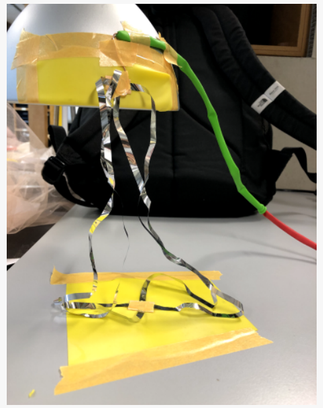
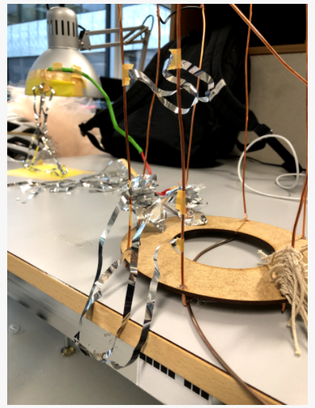
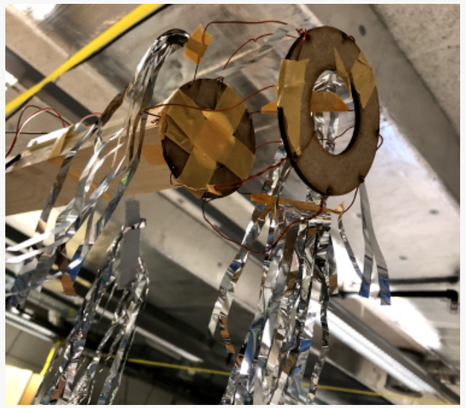
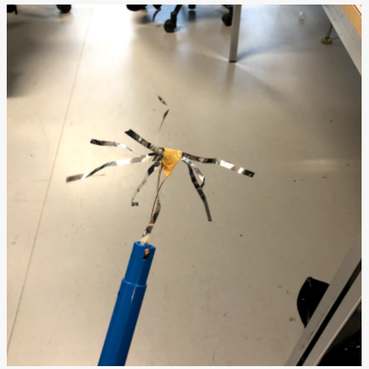
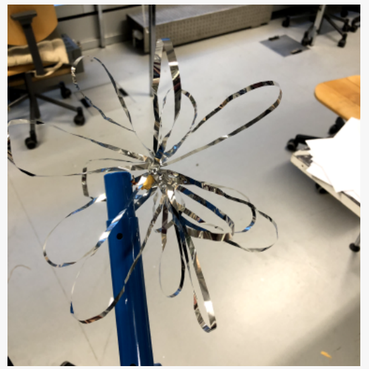
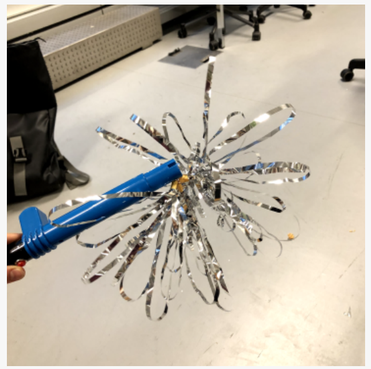


In addition we worked with Aluminum foil. We cut this into small strips or platelets and observed how it behaved. In addition, we tested whether the load can also be directed to larger areas or longer distances. This worked very well with aluminum and in combination with wire. The wire mesh also conducts very well, however, it quickly loses the charge again at its pointed ends. We also have tried wool threads. Unfortunately, the desired effect was too weak, which is why we decided to continue working with aluminum and wire.

# 02 MATERIAL



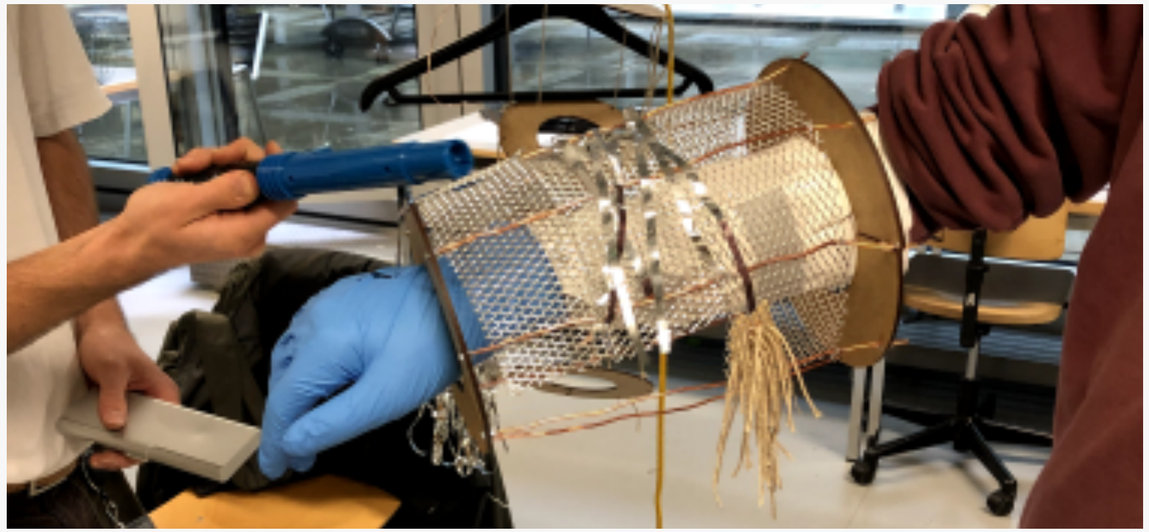



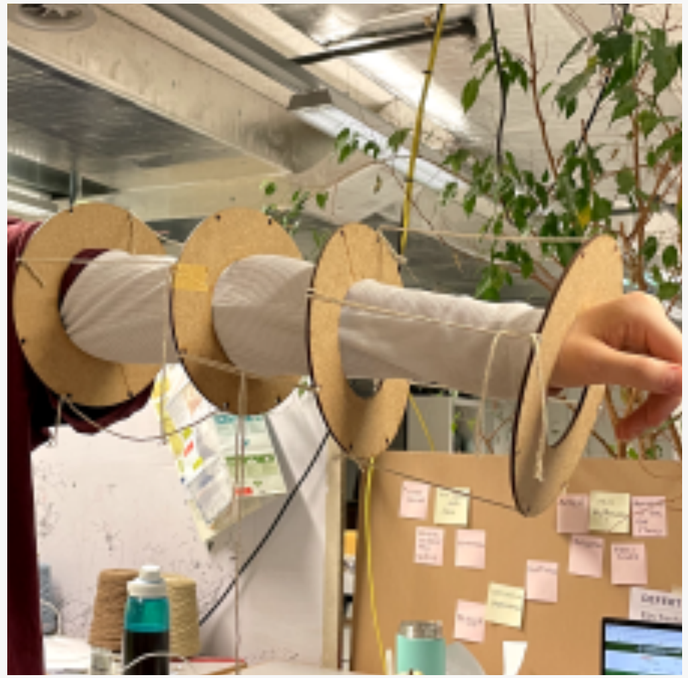








The material called "tinsel" from the Christmas decoration department, worked best and produced the greatest effect. It comes in small thin stripes and is really light which is why it stands up well. We tried out different shapes like flowers or arcs. We also experimented with the length or amount of the stripes. The combination with wire also worked very well. At this point, we think this would be a good material we want to use in our end product.

# 03 WEARABLE

In the next step we tried to bring our findings into something three-dimensional. For displaying the state of tension we chose the shoulder, neck and arm region. Because we think that this is the area where being under tension is felt. As a first idea, we tried to create an arm attachment with rings. This serves to get the cables and tinsel away from the body. It needs either a large distance so that the body does not discharge it or a thick insulation of the skin. We have tried to achieve this through the large rings, the cage and the layer of rubber around the hand. Unfortunately, this still did not work properly, because the body constantly discharged the tinsel.

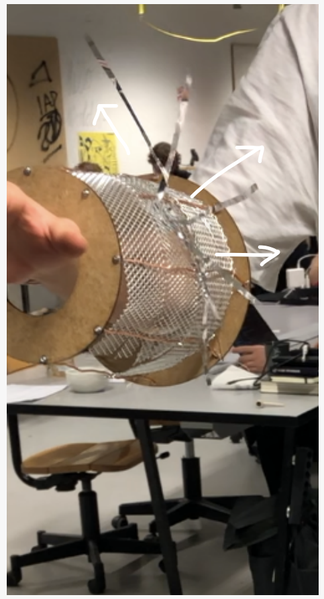


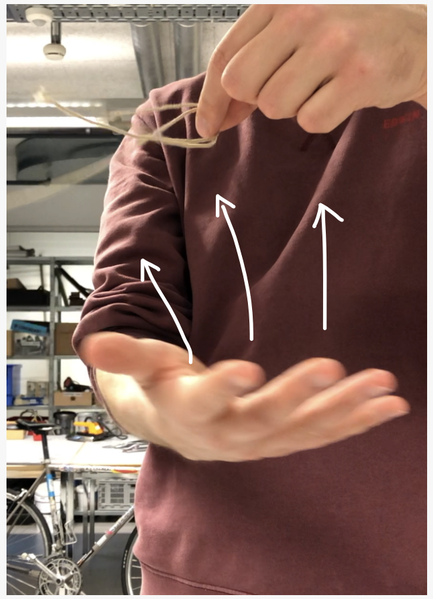



# How do we get the static charge under control?

# 05 BODY ISOLATION

Through a lot of experimentation and the big question that was in the room, "How can we best either isolate our body or create enough distance from the body?", we came up with a breakthrough idea. We realized that standing on a PVC box isolates our whole body. Since we are charged the same as the material that is attached to us, it repels and we can direct it additionally. So there is no need to build complex isolated skin around our body anymore. This means we can now design a more sleek dress and only need to build something high enough that isolate us from the ground. We have thought of a shoe here.

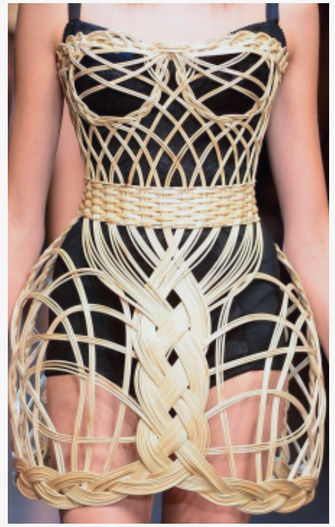



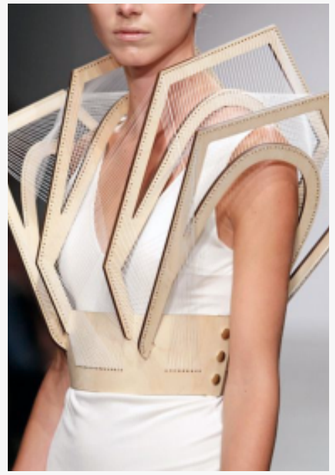


# PROTOTYPING

# 01 MOOD

mood



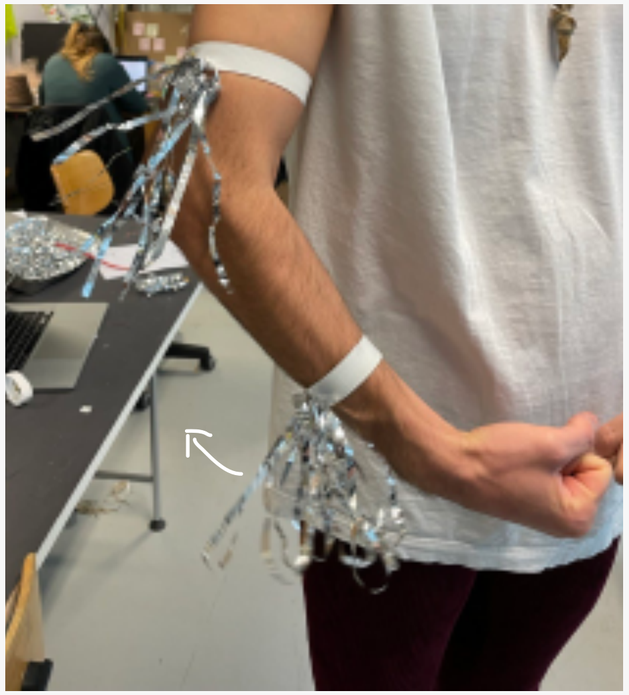


For our wearable, we are very inspired by a braided wire look. Since not every material conducts equally well and strongly how we found out, copper and alumium works best for us. We also like the optic and compination of wood and plexiglas. The result should have a handcrafted vibe.

# 02 FIRST VERSION

Our wearable now consists out of two parts. On the one hand, we need the [2] shoe that separates us from the ground with a high sole, so that the electric charge can flow through our own body. Here in the first version, we used a box out of plexiglass. Our other part of the wearable [1] is placed on the arms. The ribbons are provided with a wire and the tinsel at certain points. These threads line up in shapes depending on the strength of the electrical charge.  By touching them, they discharge and collapse.

part [1]



part [2]

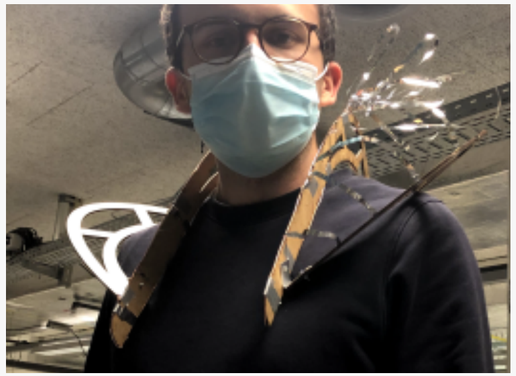
# 03 UPPER BODY [1]

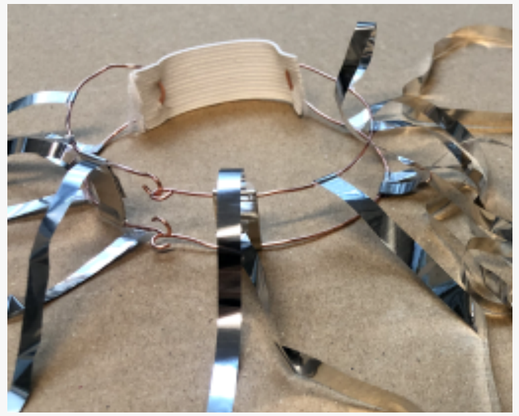
From this point on, we continued to work on part one and two separately. For the upper body, we created the first wearable. This we first prototyped with paper and cardboard. The resulting shape is then laser cut from wood.

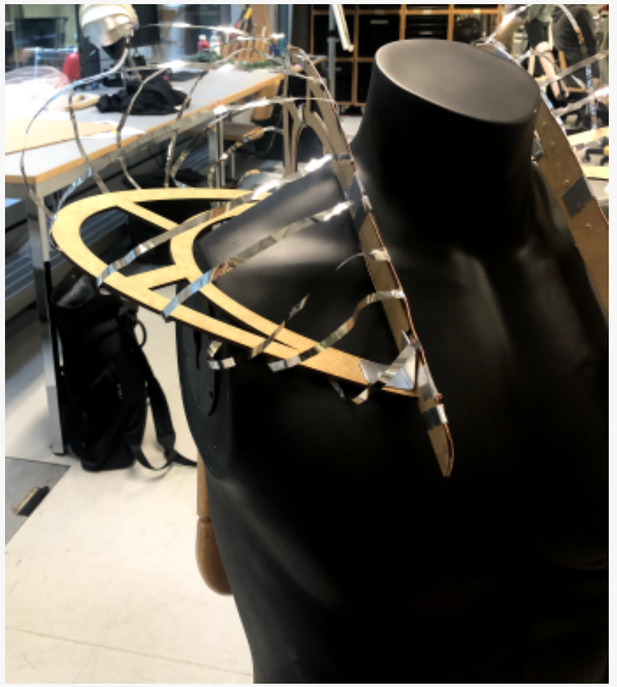
# 03 UPPER BODY [1]

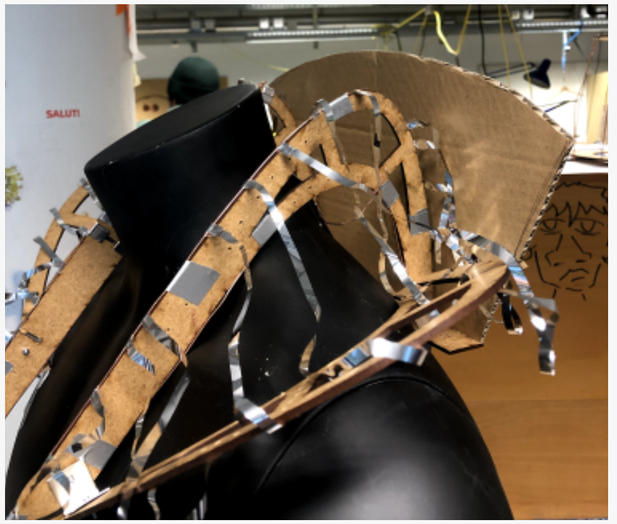
From the wooden forms has developed a portable frame that you can put on your shoulders. The frame is framed with a wire to divert the load from the body. The tinsel is also attached to the wire and thus stands up in the arches. We then extended the shoulder area and tried different methods on the arm to further increase the effect as it goes down a bit.

Advanced prototype



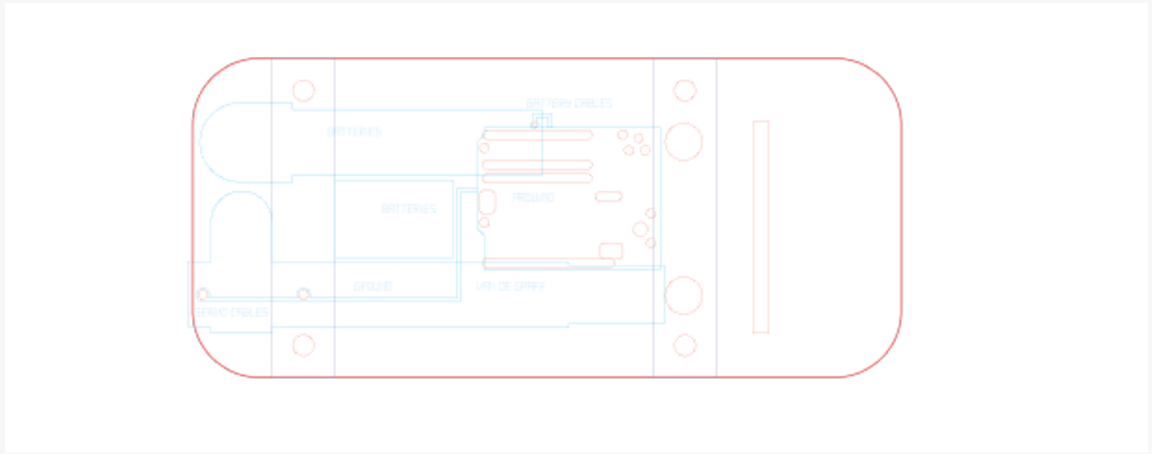


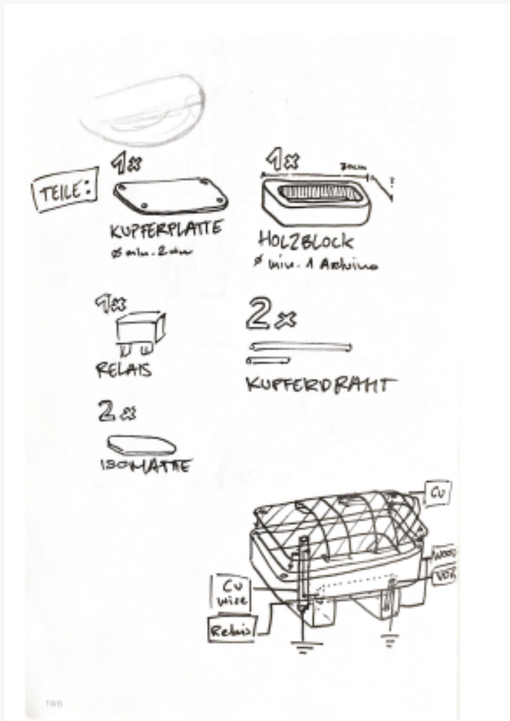


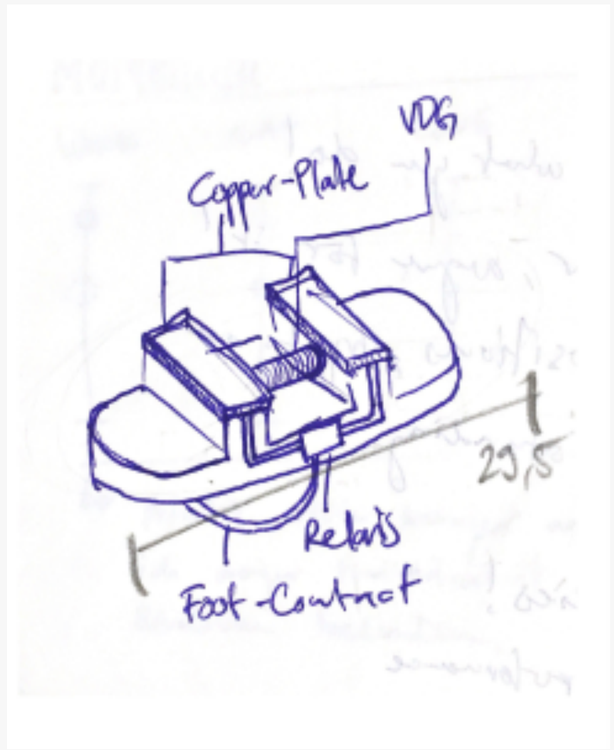


# 04 SHOES [2]

Since we no longer want to charge ourselves externally by another person we have considered integrating the mechanism into the shoe. That's why we put the "Fly Stick" between the to stilts of it. He will be regulated by an Arduino which is controled by the incoming data. Additionally, we would like to have the ability to switch between the two states of grounded and not grounded. We tried to solve that with a servo, which control the grounding mechanism. On the top of our shoe we put a cooper plate to pass the resulting charge to the body over a large area.

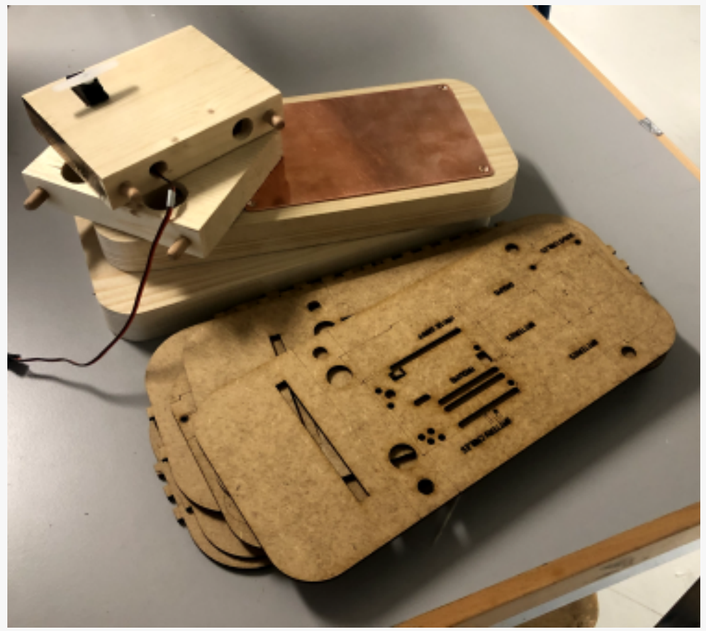


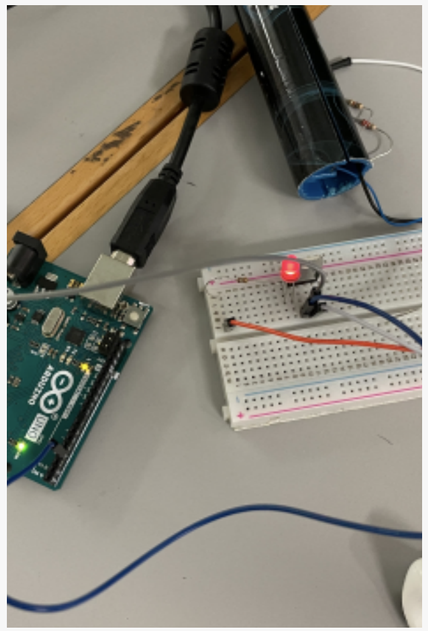



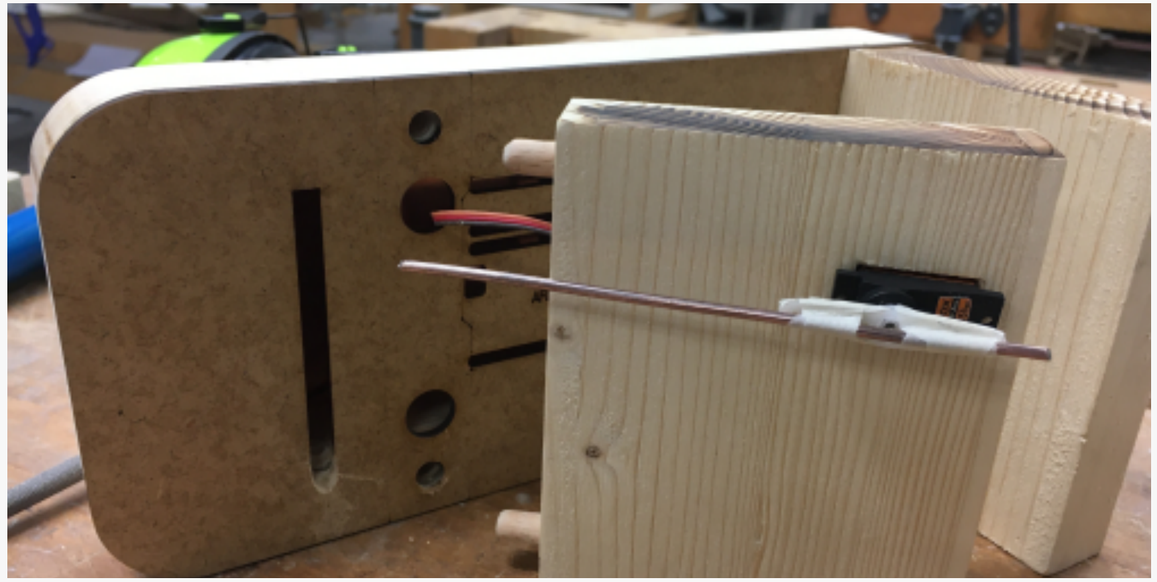
# 04 SHOES [2]

components



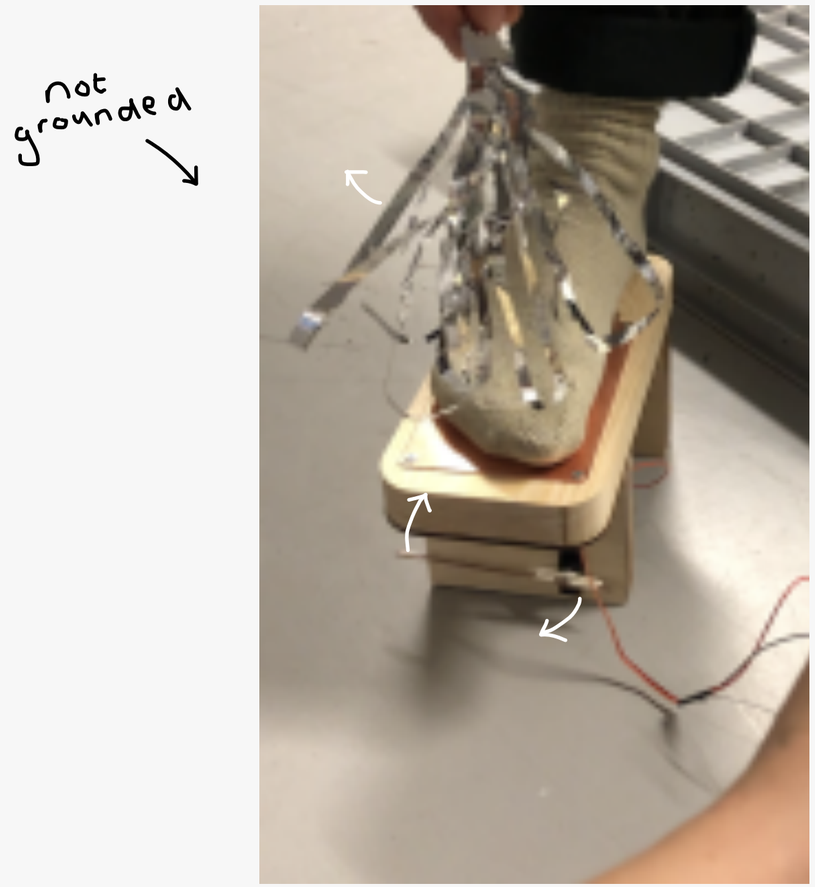


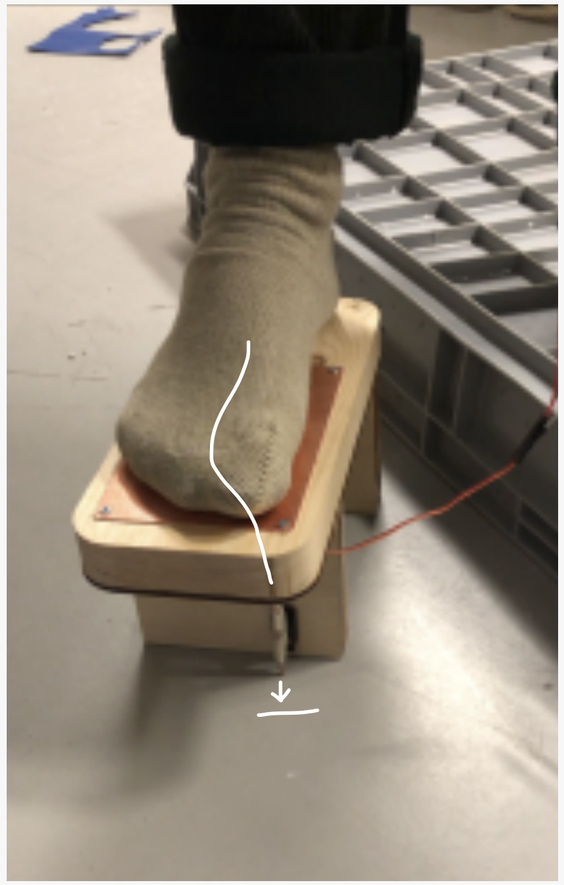
We then started to laser and saw all the necessary components out of wood. In the next step, we connected everything to each other to perform the first tests. In addition, we connected the "Fly Stick" to the Arduino and can now control it.



# 04 SHOES [2]

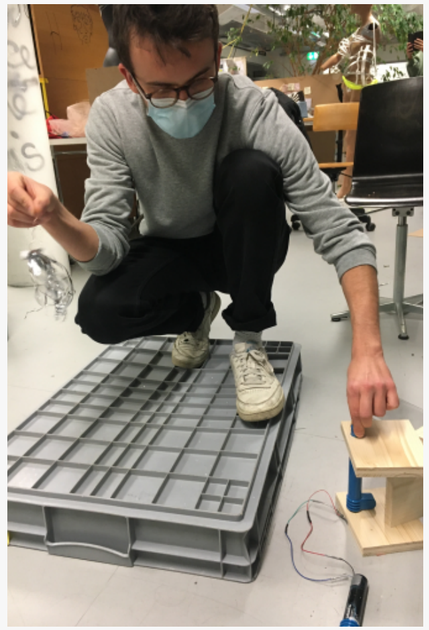
The grounding meachnism works like this. A cooper wire, controlled by a servo motor is rotating. If the wire is vertical, it connects the body with the ground in order to discharge the user. Unfortunately, that didn't work out quite as well as we hoped because there were some trouble with the high voltage an the servo. A large area for discharching on the floor is important and also a really safe connnection between wire an the floor. Otherwise it will create a few sparks that don’t discharge the body instantly.

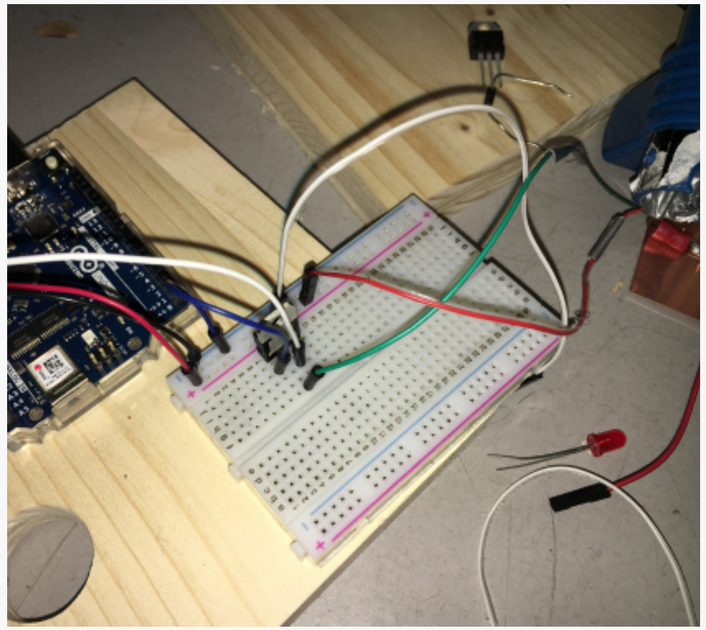


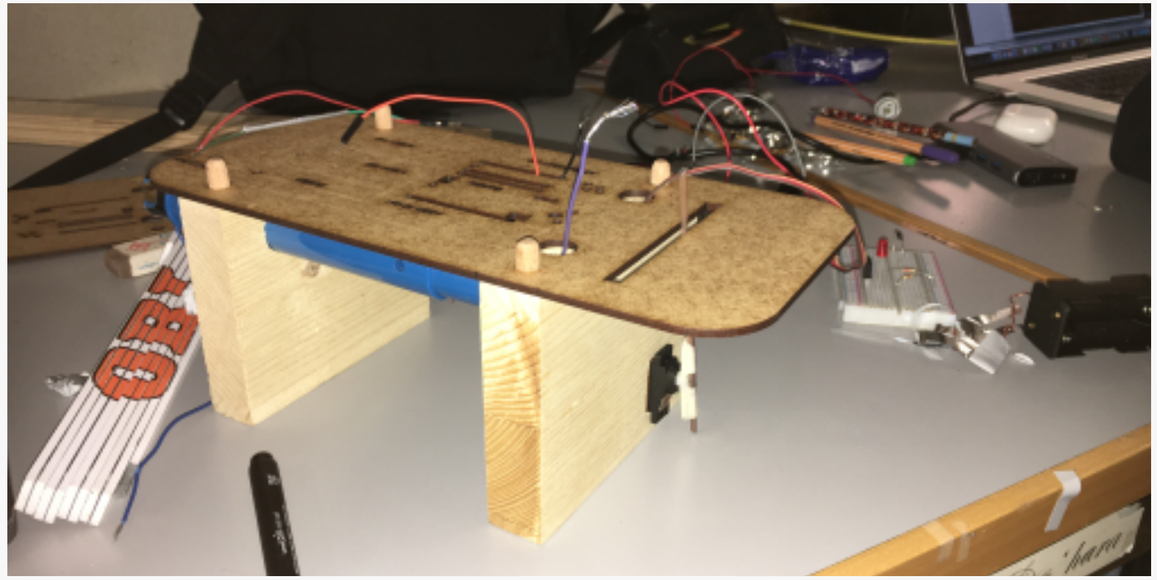



# 04 SHOES [2]

Unfortunately, after we've built the hacked Fly Stick into the shoe, we had a lot of problems keeping the static energy in the body. We couldn't exactly point out where the static energy has been lost. But in general we already knew that wood isn't the best choice regarding it's triboelectric characteristics and therefore assumed that a lot of voltage was lost because of the material and the direct contact with the stick.

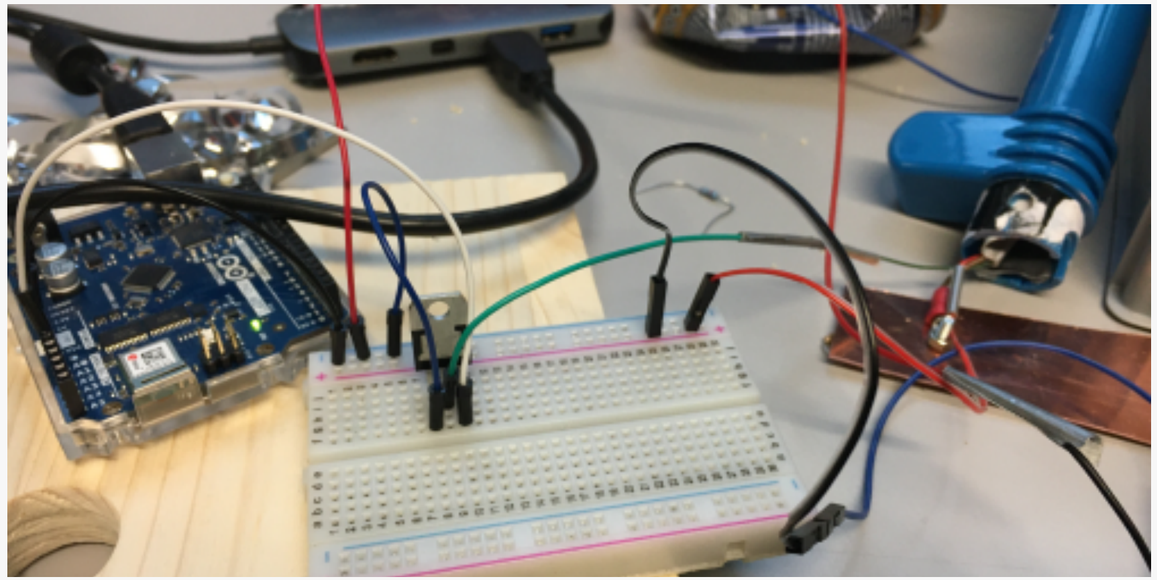


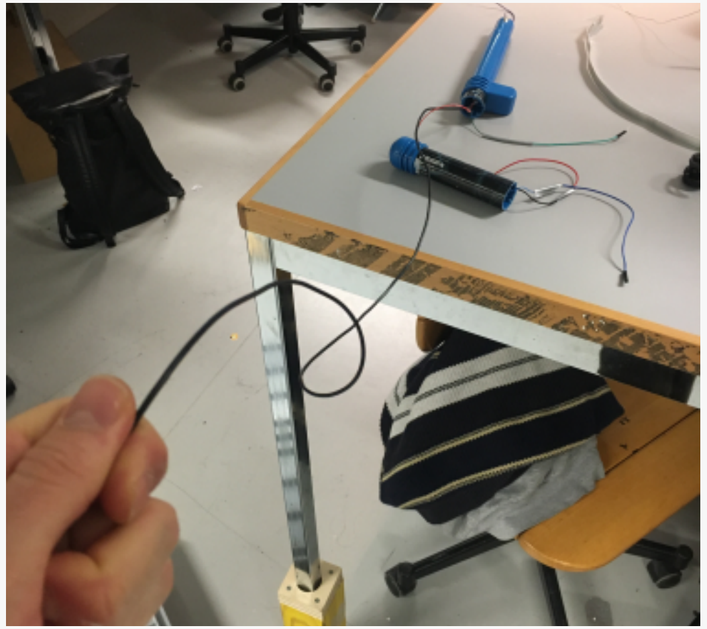


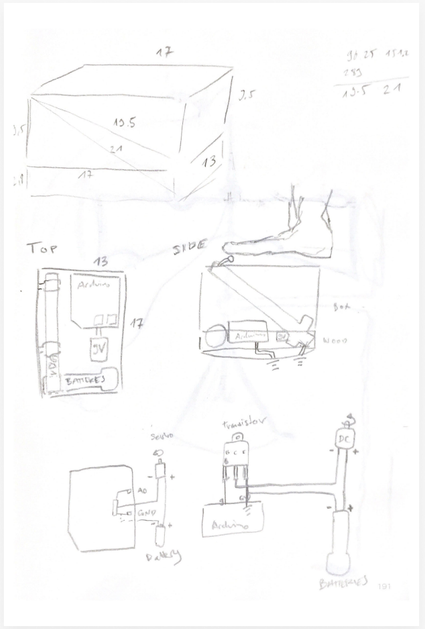


# 04 SHOES [2]

As there wasn't much time left, we decided to buy some rako boxes made from polypropylen as we already had good experiences with it. We further investigated how far and with which materials we can transfer the created voltages and came to conclusion that we should try to bring the one side of the stick as close to the body as possible whereas the other should be close to the ground.

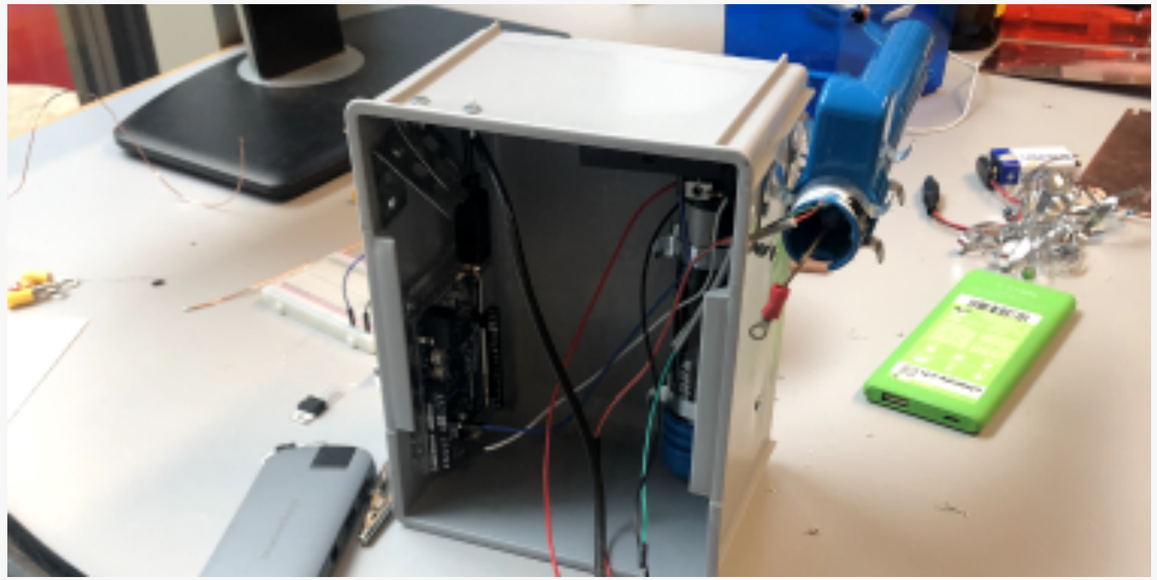


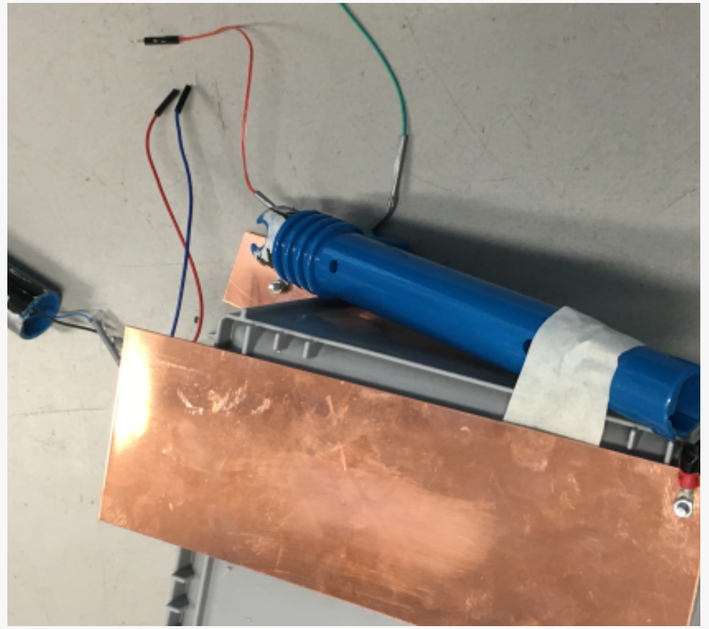


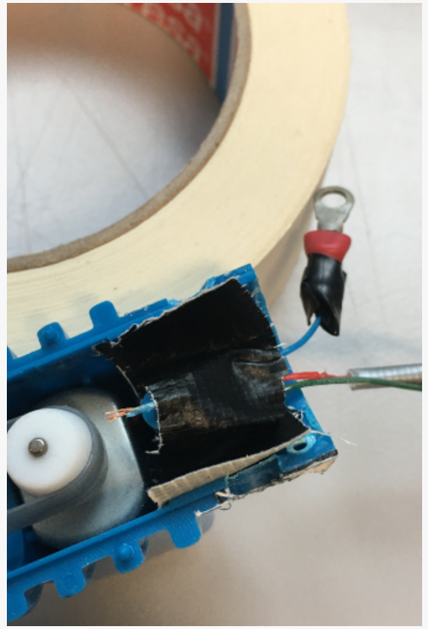


# 04 SHOES [2]

In the end we managed to keep the charge inside the body upright. But now we realised that we are not able to build high voltages really quick. Nearly nothing happend when the stick was running so we had to troubleshoot again. Apparently, the stick seemed not be grounded good enough with a copper plate only. But until now we still don’t know how we could improve this without generating a huge plate that wouldn’t make you able to walk again.



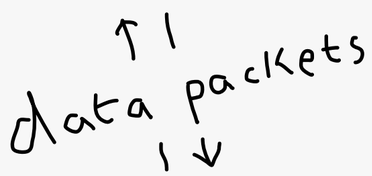


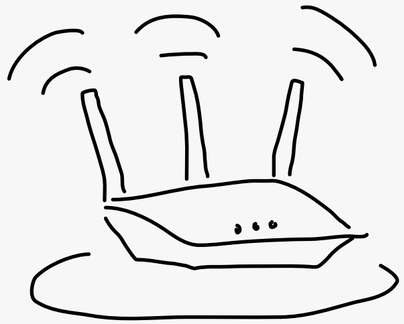


# DATA PART

# 01 ROUTER

We thought about what data can best show how stressed a person is. We first thought of using calendar data, the amount of messages and calls, screentime or the sleep cycle. Another thought was to determine the person's mental state using a combination of body data to measure stress levels. However, we then decided to track the data packets via a router in the room, as it sounded more exciting to us. The more signals the more one is charged or discharged. For this, we used a router with OpenWRT, which is an extensible firmware for routers. With that, we wanted to measure the traffic in its network. Unfortunately, we could not fully implement this idea because we could not cooperate with the Informationstechnologie-Zentrum (ITZ) due to data protection.



# 02 WEBSITE


For the final data part we than decided to create a website. The audience can visit the website which simulate to log into the "network". By clicking on the button a signal is sent to the node, which processes the signals. Each receiving signal results in a sound during the performance. If the frequency of signals is high enough, the generator in the shoe is started via a command from the node.

code

```
<html>
<head>
  <script src="https://unpkg.com/mqtt@4.0.1/dist/mqtt.js" ></script>
  <meta name="viewport" content="width=device-width, initial-scale=1.0, maximum-scale=1.0,
user-scalable=no" />
  <style>
    body {
      height: 100vh;
      display: flex;
      justify-content: center;
      align-items: center;
    }
    button {
      text-transform: uppercase;
      max-width: 350px;
      padding: 5px;
      border: none;
      background-color: blue;
      color: white;
      width: 100%;
      border-radius: 20px;
      font-size: 3em;
    }
    button:active {
      background-color: white;
      color: blue;
    }
  </style>
</head>
<body>
  <button id="button">send data</button>
  <script>
    const client = mqtt.connect('wss://embodied-interaction-3:kcUmGSrffcDQK6nI@embodied-
interaction-3.cloud.shiftr.io', {
      clientId: 'client' + Math.round(Math.random() * 1000)
    });
    client.on('connect', function() {
      console.log('connected!');
      client.subscribe('hello');
    });
    client.on('message', function(topic, message) {
      console.log(topic + ': ' + message.toString());
    });
    document.querySelector('button').addEventListener('click', function() {
      client.publish('data-package', '1');
    });
  </script>
</body>
</html>
```

The website is coded very simple. It could be improved by encouraging the user to press multiple times on the “send data” button. Then the one who is wearing the device would get a higher tension.

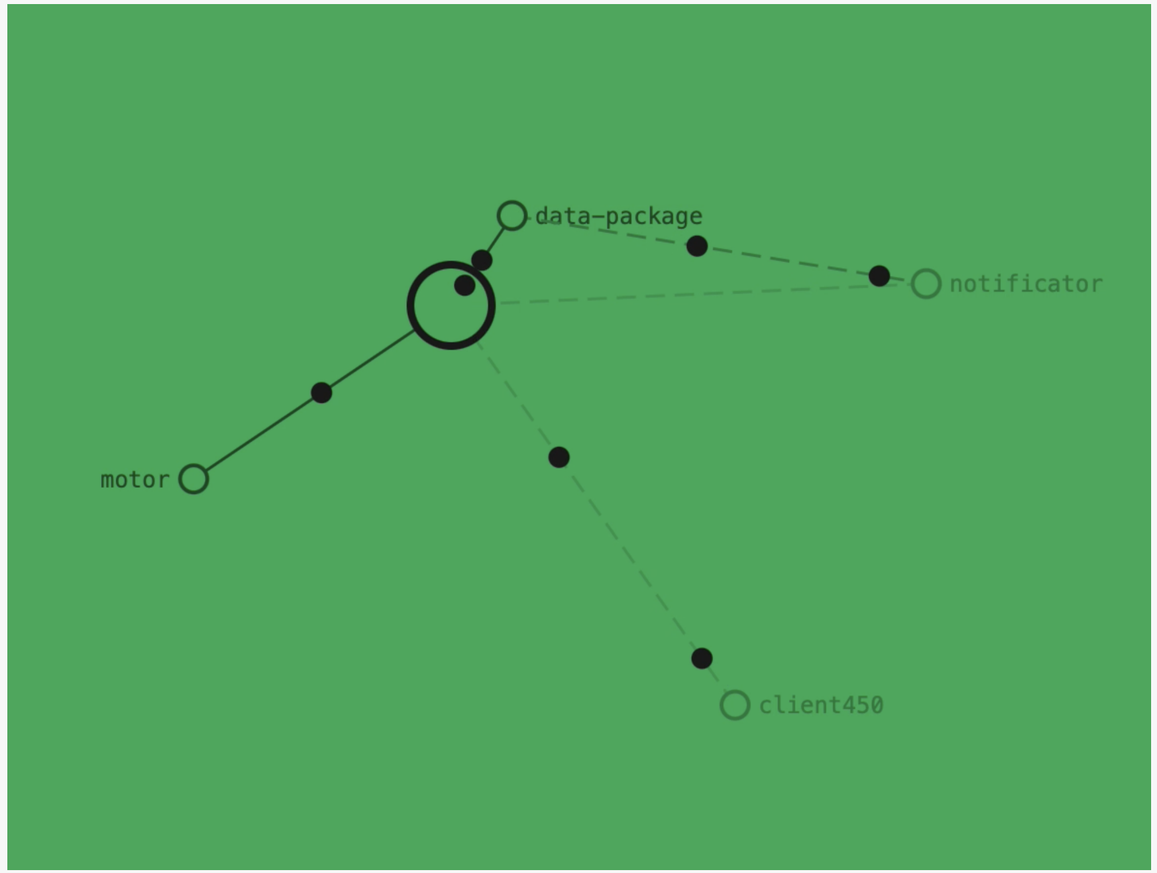
# 03 NOTIFICATOR

The notificator is the “brain” of the wearable. It processes the data and sends instuctions to the shoe.

```
var player = require('play-sound')(opts = {})
const mqtt = require('mqtt'); // skip in browser

const client = mqtt.connect('mqtt://embodied-interaction-3:kcUmGSrffcDQK6nI@embodied-
interaction-3.cloud.shiftr.io', {
  clientId: 'notificator'
});

var messages = [];
var messagesInInterval = 5;
var timeInterval = 5000;
var clearMessagesInterval = 1000;
var soundEveryMessage = 3;
var lastMotorOnEvent = 0;
var maxMotorOnEvery = 5000;

client.on('connect', function() {
  console.log('connected!');
  client.subscribe('data-package');
});

client.on('message', function(topic, message) {
  messages.push(Date.now());
  if (messages.length % soundEveryMessage === 0) {
    // $ mplayer foo.mp3
    player.play('sound'+randomIntFromInterval(1, 3)+'.wav', function(err){
      if (err) throw err
    })
  }
  console.log(topic + ': ' + message.toString());
});

function randomIntFromInterval(min, max) { // min and max included
  return Math.floor(Math.random() * (max - min + 1) + min)
}

function clearMessages() {
  console.log("clear messages");
  let referenceDate = Date.now() - timeInterval;
  messages = messages.filter((message) => {
    return message > referenceDate;
  })
  if ((messages.length / messagesInInterval) > 1 && lastMotorOnEvent < Date.now() -
maxMotorOnEvery) {
    lastMotorOnEvent = Date.now();
    client.publish('motor', '1');
    messages = [];
  } else if (lastMotorOnEvent < Date.now() - maxMotorOnEvery) {
    client.publish('motor', '1');
  }
}

setInterval(() => {
  clearMessages();
}, clearMessagesInterval)
```

# 04 SHIFTR.IO

To exchange data between the three parts of our wearable, we used shifter.io. All clients that visit the website, can send data-packages to the “notificator”. In case a defined frequency is reached, the motor in the shoe is turned on or off.



```
#include <Servo.h>

/* WIFI MQTT*/
#include <ArduinoMqttClient.h>
#if defined(ARDUINO_SAMD_MKRWIFI1010) || defined(ARDUINO_SAMD_NANO_33_IOT) ||
defined(ARDUINO_AVR_UNO_WIFI_REV2)
#include <WiFiNINA.h>
#elif defined(ARDUINO_SAMD_MKR1000)
#include <WiFi101.h>
#elif defined(ARDUINO_ESP8266_ESP12)
#include <ESP8266WiFi.h>
#endif

#include "arduino_secrets.h"
//////please enter your sensitive data in the Secret tab/arduino_secrets.h
char ssid[] = SECRET_SSID;    // your network SSID (name)
char pass[] = SECRET_PASS;    // your network password (use for WPA, or use as key for
WEP)

WiFiClient wifiClient;
MqttClient mqttClient(wifiClient);

const char broker[] = "embodied-interaction-3.cloud.shiftr.io";
int        port     = 1883;
const char topic[]  = "motor";

/*SERVO AND VAN DE GRAAFF*/

int pinNumberMotorOnOff = 4;
int pinNumberServo = 9;
int timeIntervalMotorOn = 5000;


Servo myservo;  // create servo object to control a servo
// twelve servo objects can be created on most boards

int servoSpeed = 15; //smaller = faster
int servoPosition = 0;
int servoUpPosition = 90;
int servoDownPosition = 0;
int servoStepDelay = 15;

char username[] = "embodied-interaction-3";
char token[] = "kcUmGSrffcDQK6nI";

void setup() {
  //750-2250 /servo position is 111 = 90° -> map(0, 0, 145, 0, 180);
  //myservo.attach(pinNumberServo, 750, 2250);  // attaches the servo on pin 9 to the
servo object
  pinMode(pinNumberMotorOnOff, OUTPUT);

  Serial.begin(9600);

  /*MQTT*/

  // attempt to connect to Wifi network:
  Serial.print("Attempting to connect to WPA SSID: ");
  Serial.println(ssid);
  while (WiFi.begin(ssid, pass) != WL_CONNECTED) {
    // failed, retry
    Serial.print(".");
    delay(5000);
  }

  Serial.println("You're connected to the network");
  Serial.println();

  // You can provide a unique client ID, if not set the library uses Arduino-millis()
  // Each client must have a unique client ID
  // mqttClient.setId("clientId");

  // You can provide a username and password for authentication
  mqttClient.setUsernamePassword(username, token);

  Serial.print("Attempting to connect to the MQTT broker: ");
  Serial.println(broker);

  if (!mqttClient.connect(broker, port)) {
    Serial.print("MQTT connection failed! Error code = ");
    Serial.println(mqttClient.connectError());
    while (1);
  }

  // subscribe to a topic
  mqttClient.subscribe(topic);

  // set the message receive callback
  mqttClient.onMessage(onMqttMessage);
}

void onMqttMessage(int messageSize) {
  while (mqttClient.available()) {
    char response = mqttClient.read();

    if (response == '0') {
      motorOff();
    } else {
      motorOn();
    }
  }
}

void motorOn() {
  digitalWrite(pinNumberMotorOnOff, HIGH);
}

void motorOff() {
  digitalWrite(pinNumberMotorOnOff, LOW);
}

void loop() {
  mqttClient.poll();
  delay(20);
}
```

The arduino in the shoe listens on the “motor” topic. If it receives an “on”-state from the notificator it turns the motor of the Van De Graaff generator on until a “off”-signal is received.

Embodied Interaction HS2021

# IMPLEMENTATION

# 01 UPPER BODY

For the final product we added a third arc at the shoulder to be able to attach more tinsel and create a large area for the effect. For the arms and one foot, we also designed bands of rubber and wire that you can easily put on and take off.

# 02 SHOE

We ended up attaching all the electronics to the rako boxes and using cords to tigh them to the foot. We still not arrived where we wanted to be in terms of functionality which is why the final shoe is still in a low prototype stadium.
We decided on using a copper plate near the stick to ground the one side of the van de graaff generator and a band attached with a copper wire that is directly taking up all the charges by functioning as a brush. Like that we don’t lose a lot of voltages in the transfer to the body.

But still both the the grounding and the charging part of the shoe need to be further improved by testing out different materials and compositions.