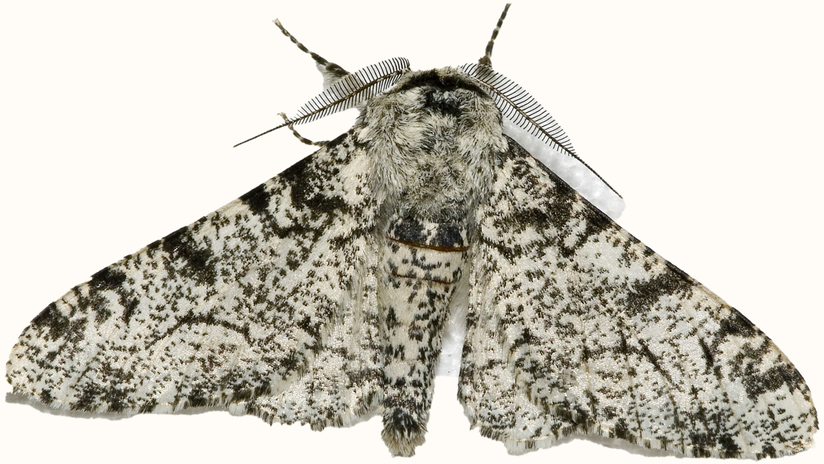
BETULARIA

CYBORG CRAFTS



MARY ETTA WEST & SANDRA BAE

VISION

A wearable glove that detects and mitigates the effects of stress caused by sudden changes in internal states and communicates these physical reactions to the external world using a dynamic color changing display

Fig. 1 Second prototype of the sensing and controlling hardware and haptics

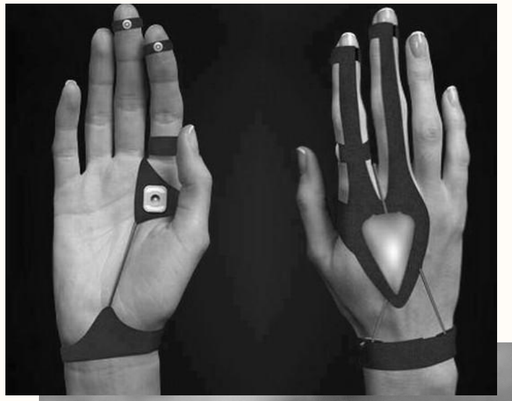
Note: I was responsible for the glove and coil, but not The Cell. I used a laser cut piece of felt to model The Cell to prepare the wiring connections for Sandra's part of the project. I then shipped the bracelet to her so she could integrate the cell and shoot the video.

INSPIRATION

Reactionary Color Change in Nature

- Camouflage as a form of expression
- The environmental causes of changes in internal states

The evolution of the peppered moth is a reactionary tale of the industrial revolution[1]. The black soot that covered the trees in Birmingham, England exposed the typica peppered moth to prey. Within a few years, 98% of the peppered moth population became melanic to blend in with the newly polluted environment. In Dorset, England however, a much cleaner environment, showed the numbers of light-colored moths flourishing as their black and white patterns were effective camouflage within the forests. This inspiration also harmonized with the Cyborg Crafts collaboration as our aesthetic preferences merged - While we are both inspired by nature, I am particularly inspired by the beauty found in the harsh, in pigmentless wings and webs, systems that create stasis, violent changes in states of matter, how high winds and crashing waves smooth the Earth, the processes that produce pearls and minerals, and the movement of frozen tides. We set out to create an eerie yet familiar piece of clothing with personal meaning - we played on each other's strengths and shared our knowledge along the way.



Peppered Moth (typica & carbonaria)

Fig 2. From top left: Wearable glove concept: https://imgur.com/BWmtOhWm , Jewelry designed by Kimberly Ovitz, and the peppered moth courtesy of an unlinked pin on Pinterest

Research Questions

1

Identity

Can we explore/ exploit the sense of touch to create relationships between humans and technology to view technology not as tools but as an inseparable dimension of our identity?

2

Interaction

What are the implications of sharing internal states with the outside world? Can haptic feedback provide real-time stress mitigation? How can the expression of internal states be used in the future of human-machine interaction?

3

Self-Learning/ Sense of Control

Can real-time stress recognition and mitigation endow users with a sense of data ownership and a sense of control over their responses to unwanted or unexpected changes in their environment?

https://github.com/ADataDate/Betularia

Materials & Tools

The Cell

Ecoflex 00-33, cell mold, black-to-white thermochromic pigment, 4x4 polyethylene plastic, squeeze bottle with precision tips, conductive heater fabric, eyelets

Haptics

3” embroidery hoop, stretchy cord for warp threads, 32 AWG wire for weft thread, and magnet

Bracelet

PVA foam, interfacing, velcro, and vinyl, felt

Circuit

MAX30105 particle sensor, SEEED studio GSR, TIP120 transistor x3, 1K OHM resistor, 10uF capacitor x 3; Qduino Microcontroller, 3.7 LiPo battery x 2, 5V boost regulator; 9V battery, 28 AWG silicone coated stranded wire, heat shrink, and hand-made electrodes from conductive fabric

Tools

Soldering station, laser cutter, 3D printer, heat gun, hot glue, wire strippers, super glue, x-acto knife

TECHNIQUES

1

WEAVING

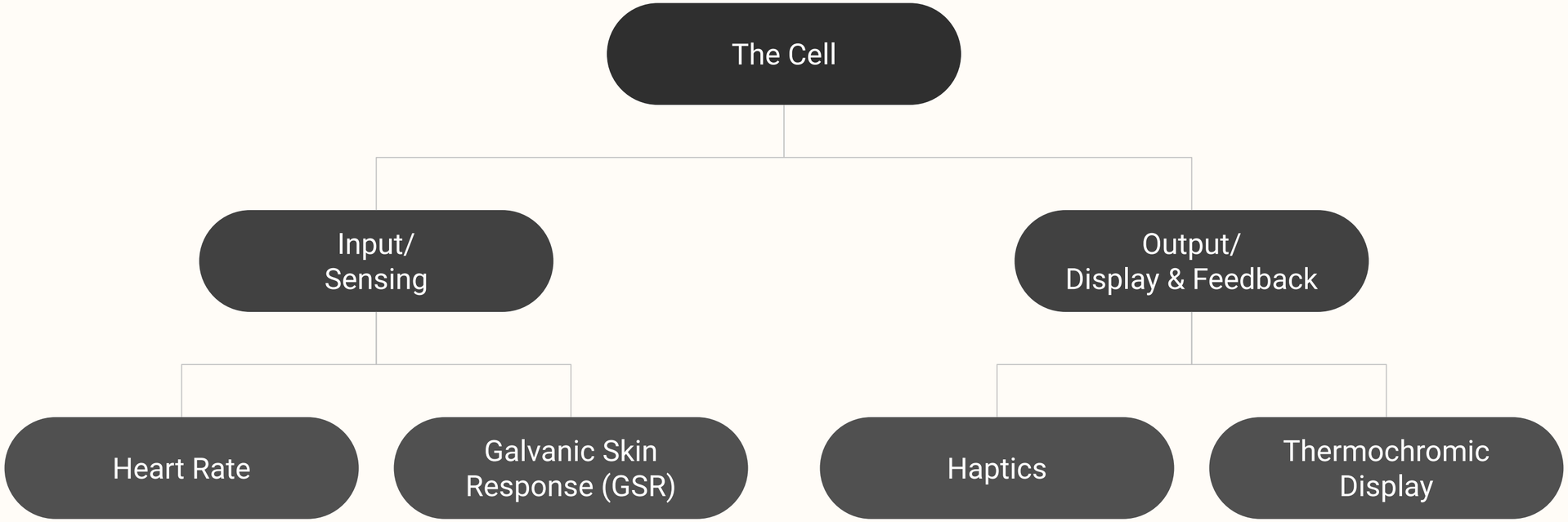
A PWM signals controls current through circular woven coil that interacts with a magnet to produce haptic effects. The coil is constructed using stretchy cord for the warp and wire wrapping wire for the weft.

2

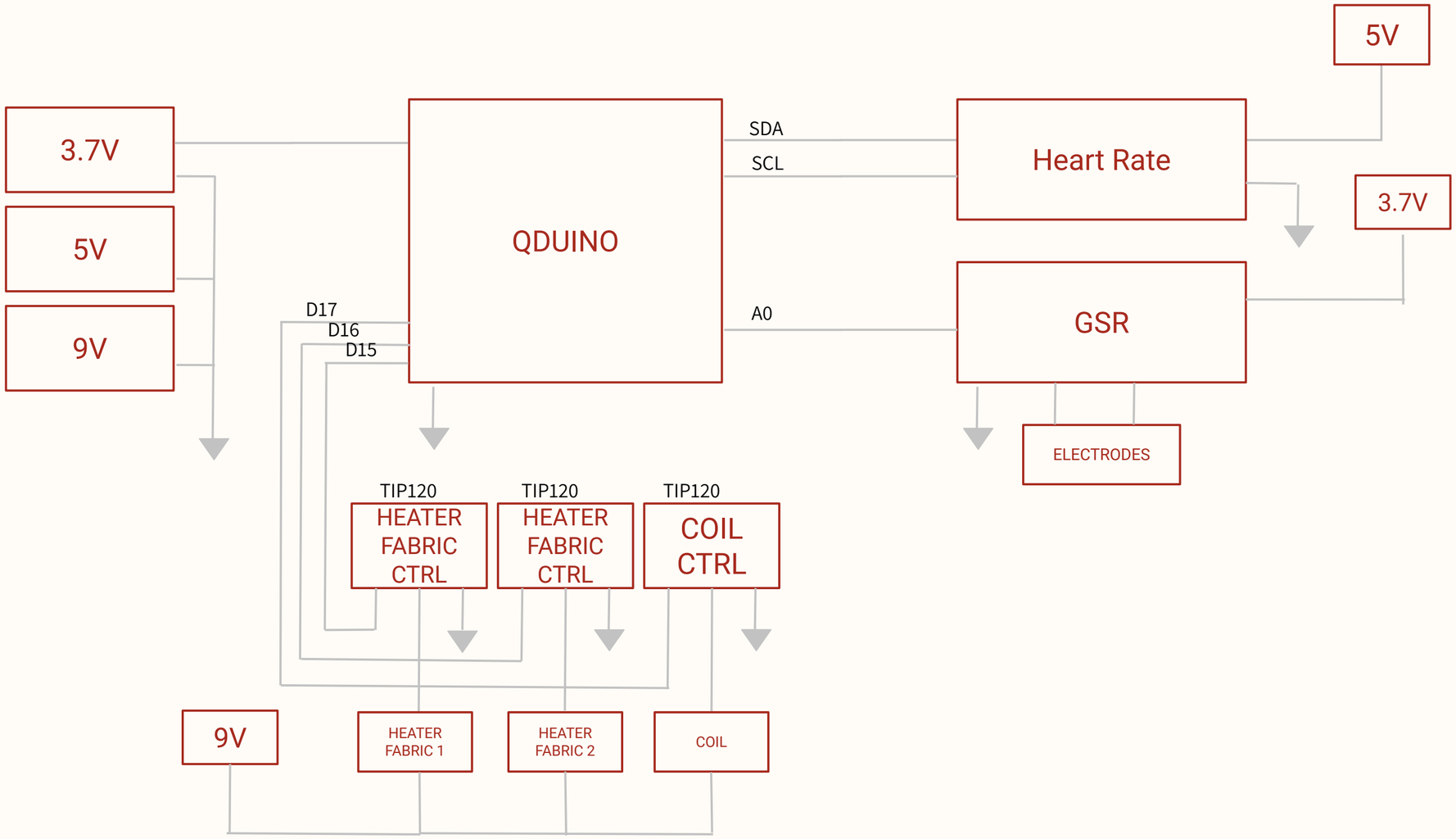
3D PRINTING / LASER CUTTING

3D printing was utilized to model the cell for remote collaborative work and to create the mold used in making the cell. A laser cutter was used for the cellular structure seen in the bracelet design.

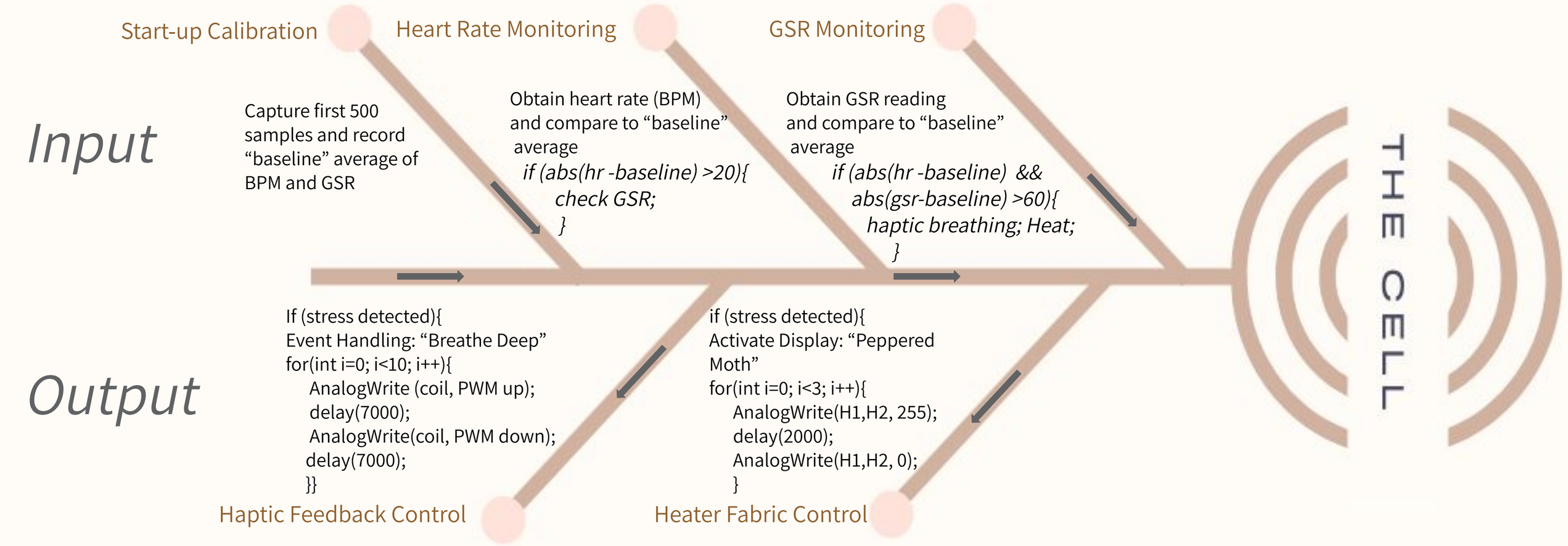
SYSTEM OVERVIEW



CIRCUIT DESIGN

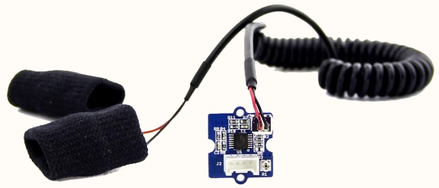


Control Logic



Bio-sensing

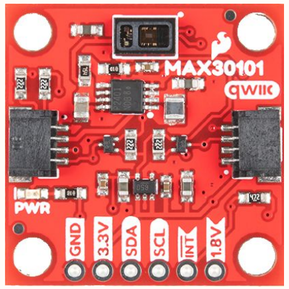
GSR



Galvanic Skin Response

SEEED Studio’s Grove GSR module is used in conjunction with handmade electrodes placed on the palm to capture sudden changes in the skin’s capacitance. This has been a tested method in the detection of stress[2].

HR



Heart Rate

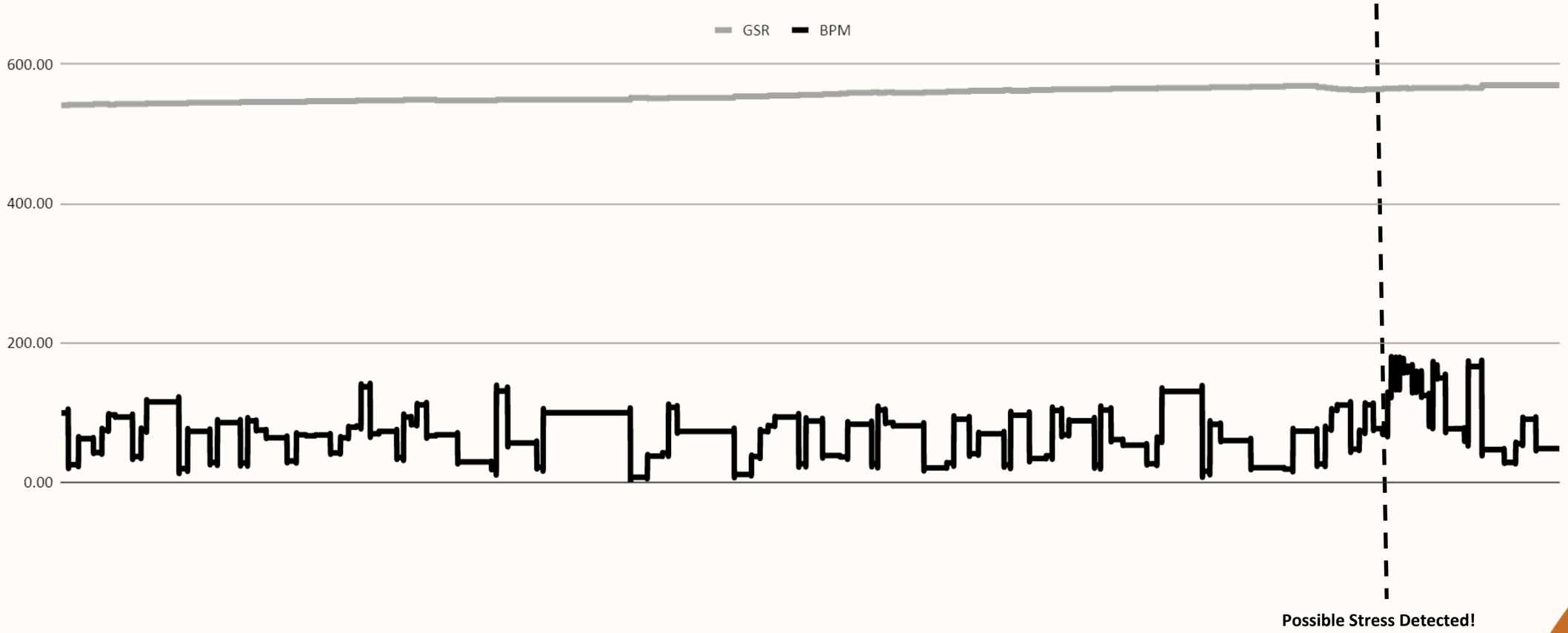
SparkFun Electronics’ MAX30105 Particle Sensor breakout board is a pulse oximeter which illuminates the skin and measures the changes in the reflection of light. During a cardiac cycle the heart pumps blood which changes the amount of blood in the radial artery - in this specific application - which will reflect more light[3].

mw

GSR Electrodes

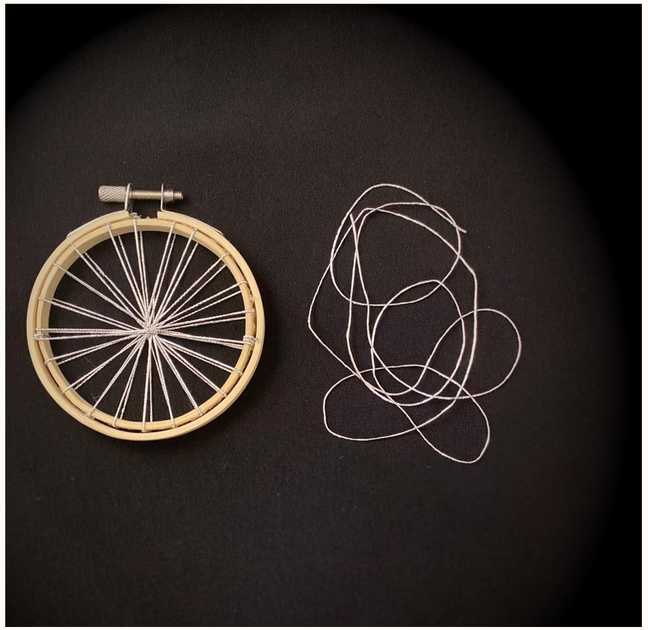
Two electrodes are made by joining a conductive fabric with a heavy weight non-conductive fabric using interfacing along with a long strip of wire between the two fabrics. The electrodes are attached to the palm side[of the glove.

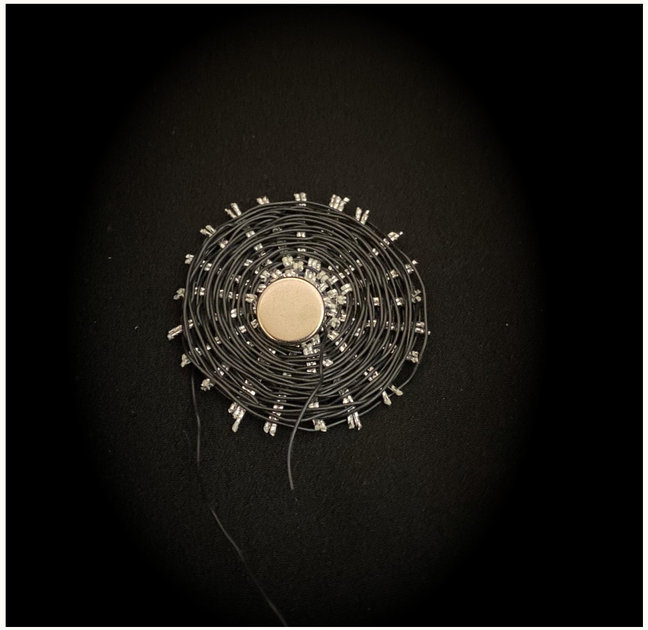
Data Collection



Please see our github repo for code: https://github.com/ADataDate/Betularia

Weaving the Coil





There were many advantages to experimenting with electromagnetics through weaving[4]:

- Quick Iteration
  - quickly increase/decrease coil size
  - quickly alter the distance between turns
- Stretchy cord for the warp made weaving in a small space possible as the warp could be lifted several inches high to allow for the shuttle to pass through

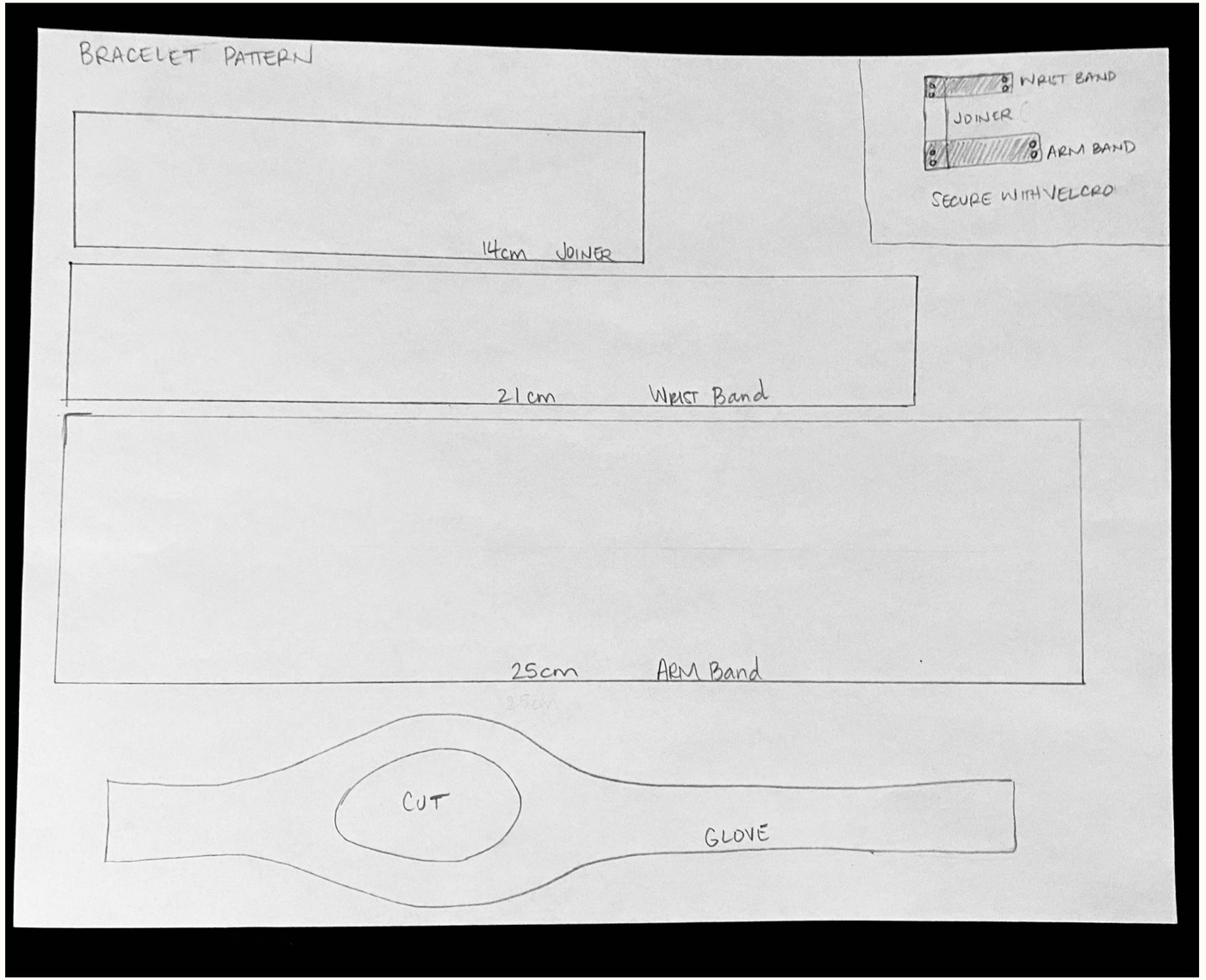
It was difficult to capture the haptics in action, but the video on the right shows the movement of chain that is attracted to the magnet while a PWM signal is “ramping” the intensity of the vibration.

Glove Design & Iteration

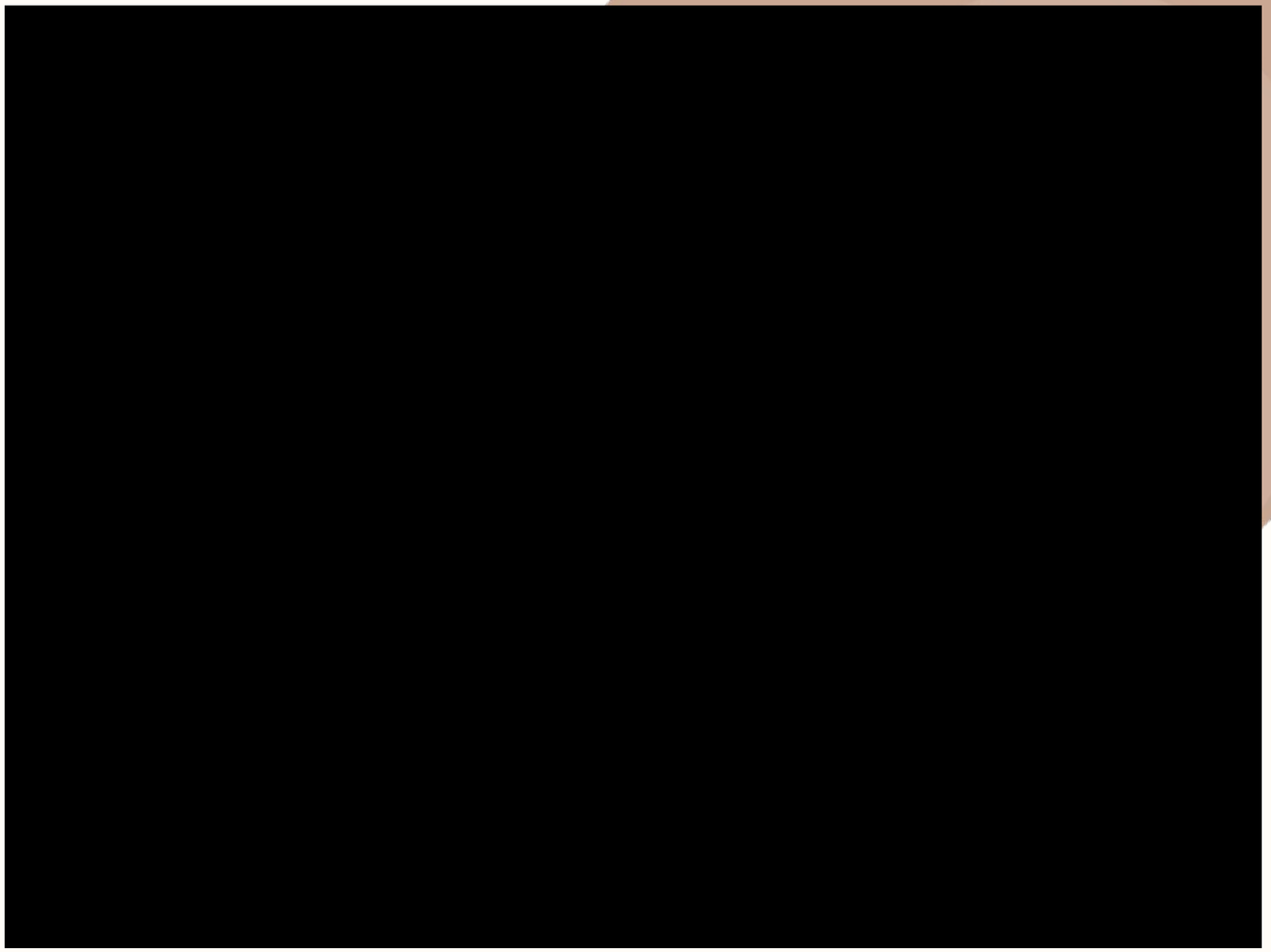
A 3D printed bracelet acted as a the first iteration of the enclosure. When I attached the coil and the felt Cell cut-out, the overall feel was bulky and uncomfortable. We opted for a new thinner design with more area to spread the electronics out. We also didn't want the look of the bracelet to compete with the thermochromic display. Laser cut vinyl in the shape of cellular structures tied The Cell and the glove together. (Design files are in the github repo).

Inspiration photo in background: Voft Knit by Valeriya Olkhova

Bracelet Pattern



Final Prototype: *Collaboration with Sandra Bae*



Video directed, shot, and edited by Sandra Bae.

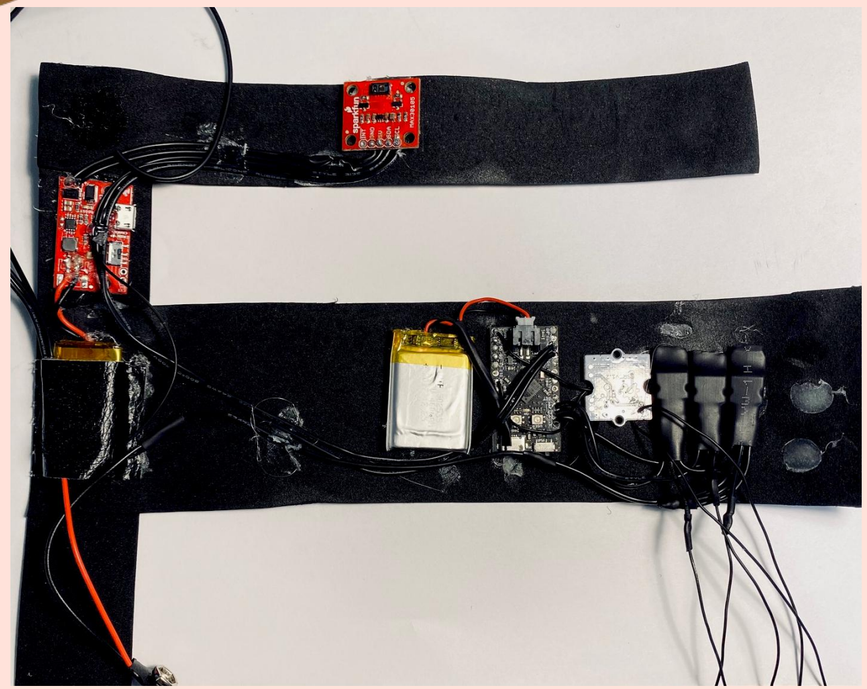
Reflection

I wore this glove for a few hours and found that wearing it on my hand was not practical. I took a moment to think about why I chose to make a glove and I realized it is because my hands are the most accessible part of my body - always in view and ready to manipulate things in the environment. I also needed access to an artery and a location for GSR electrodes that happen to be in the same vicinity. But, I couldn't wash my hands, or run my fingers through my hair or pull on my overcoat with ease. I have learned to design hands-free because of this project.

I found the haptic feedback to be soft and effective. Once triggered, the intensity of the vibration grew with a PWM signal from 0-255 over a period of 7 seconds and then reduces in intensity from 255-0 over a period of 7 seconds. This process is repeated 10 times and encourages deep breathing exercises. Even when it triggered falsely or when I didn't want to comply it still felt good - a gentle hand massage. In an early stage of the prototype the vibration merely mimicked heart beats. What I noticed is that I became "numb" to the sensation and it no longer held meaning after just a few minutes. The Breathe Deep algorithm on the other hand has a focused purpose and held my attention - I would like to know if others feel the same. This has also inspired some research and a possible future study on haptics - how many gestures we recognize that can be attributed to some meaning and how long before we ignore them.

The collaboration with Sandra Bae has been nothing shy of magical. We truly played on each other's strengths and skill shared along the way. I am in awe of her knowing, work ethic, design aesthetic, her inspiration, her meticulousness, and communication style. I can't say enough good things about working with her.

Reflection (part 2)



Weaving > Wiring

Bulk. Heat.

Hidden in the bracelet is a mess of wiring, batteries, and sensors (Though surprisingly wearable because of the spacing of the parts that lends itself well to rolling around the arm). If this glove were be to designed as a woven electronic textile then all the wiring would be built-in. This, coupled with a custom flex PCB will reduce the footprint, increase comfort, and be more aesthetically pleasing. Routing this for function and comfort was a challenge.

Future Work

- Shift to a hands-free design (e.g., bracelet)
- Automated “squeezing” (deep touch pressure therapy[6]) with shape memory alloy
- Replace electronics with single flex PCB
- Integrate textile and wiring with a woven structure
- Move to SAMD51 microcontroller to run TinyML or TensorFlow

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Thank you!