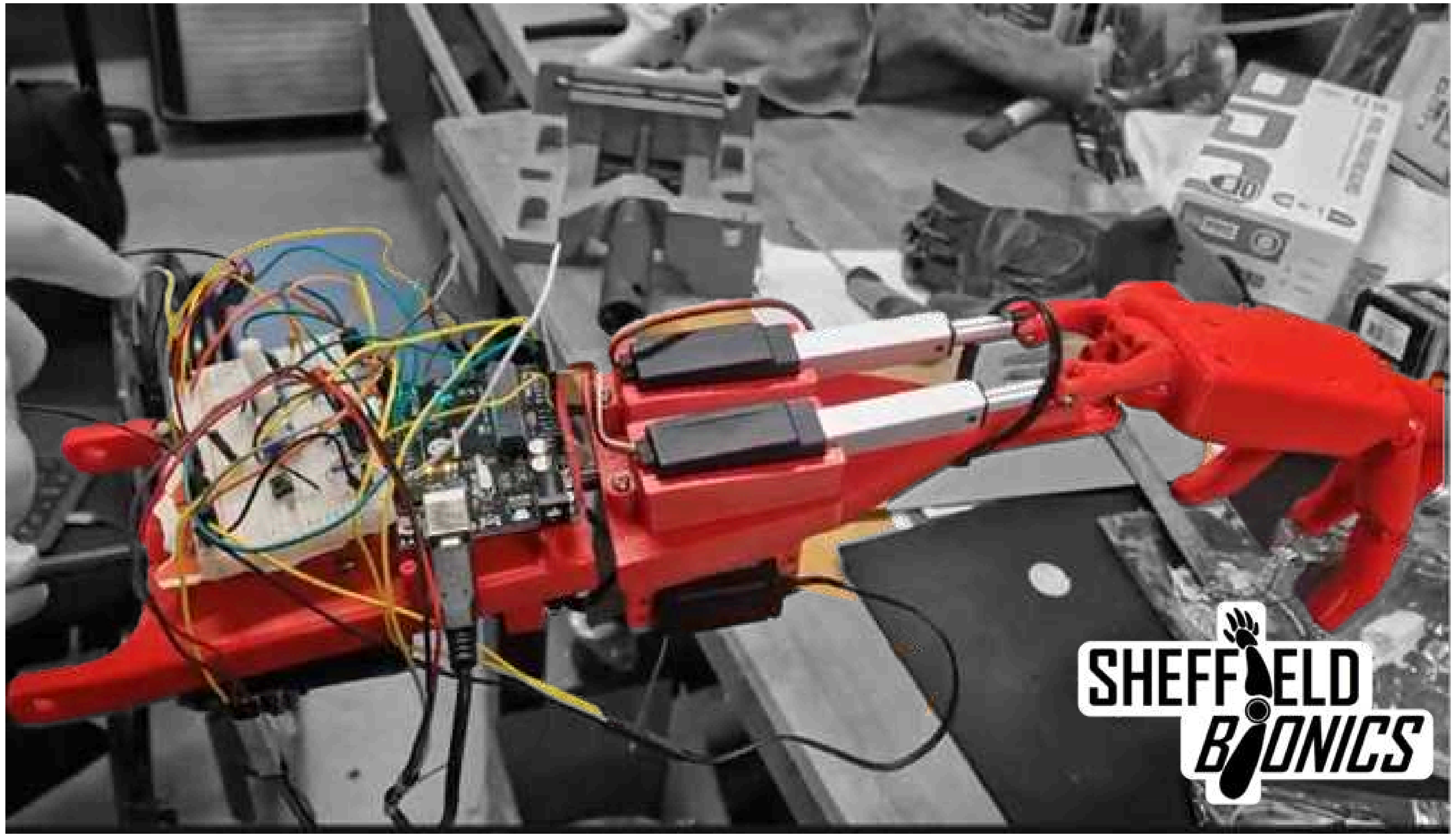
Tobias Kunz

Portfolio

Building a
“rebubbling” rig to test
Cuckoo Spit, summer
research



Sheffield Bionics

Prosthetic Arm Project lead: creating a device for a real patient. University volunteer group project

Key skills: Human-centred design, project management, design ideation, rapid prototpying, microprocessor programming, relationship building

I recruited a physio in the university, who helped loosen his muscle tightness caused by limb imbalances

(patient blurred for privacy)

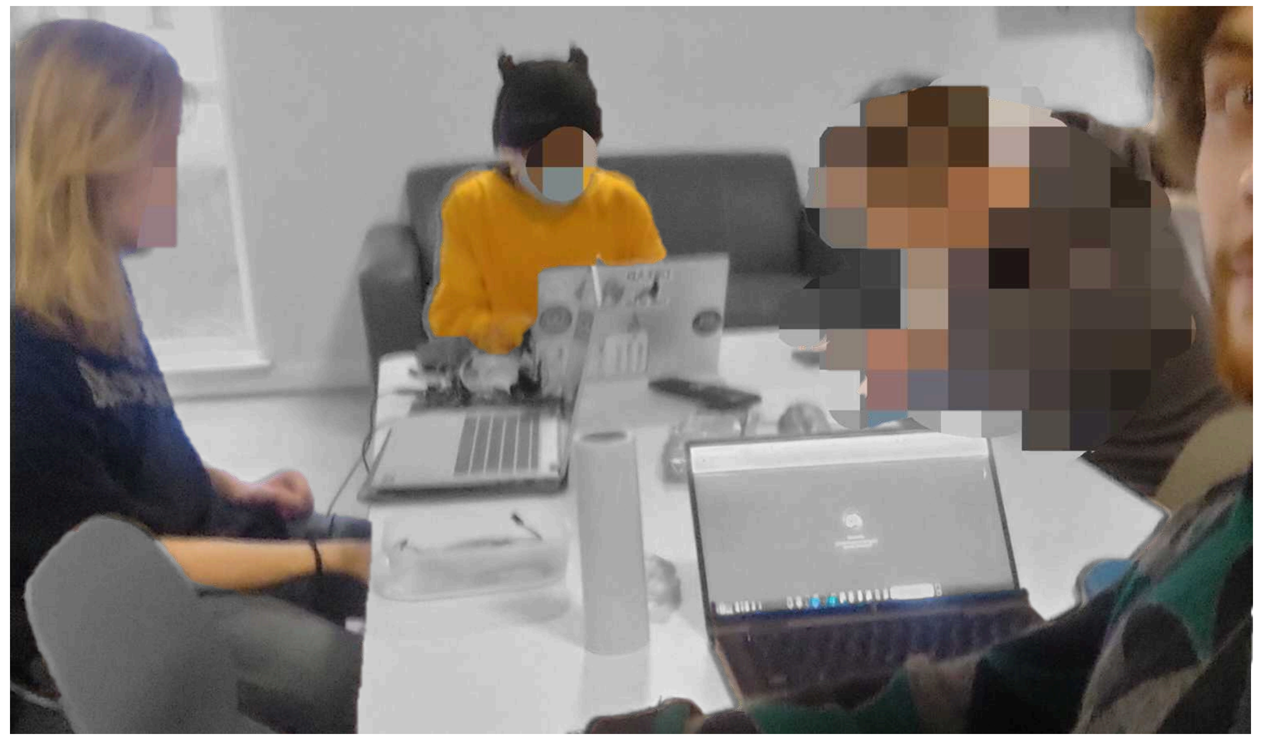
I reconnected with a previous sponsor, who offered a free bespoke interfacing cup

A student led project with impact

It was the start of the 2023 term at University of Sheffield.
Sheffield Bionics' Arm Project was in a sorry state:

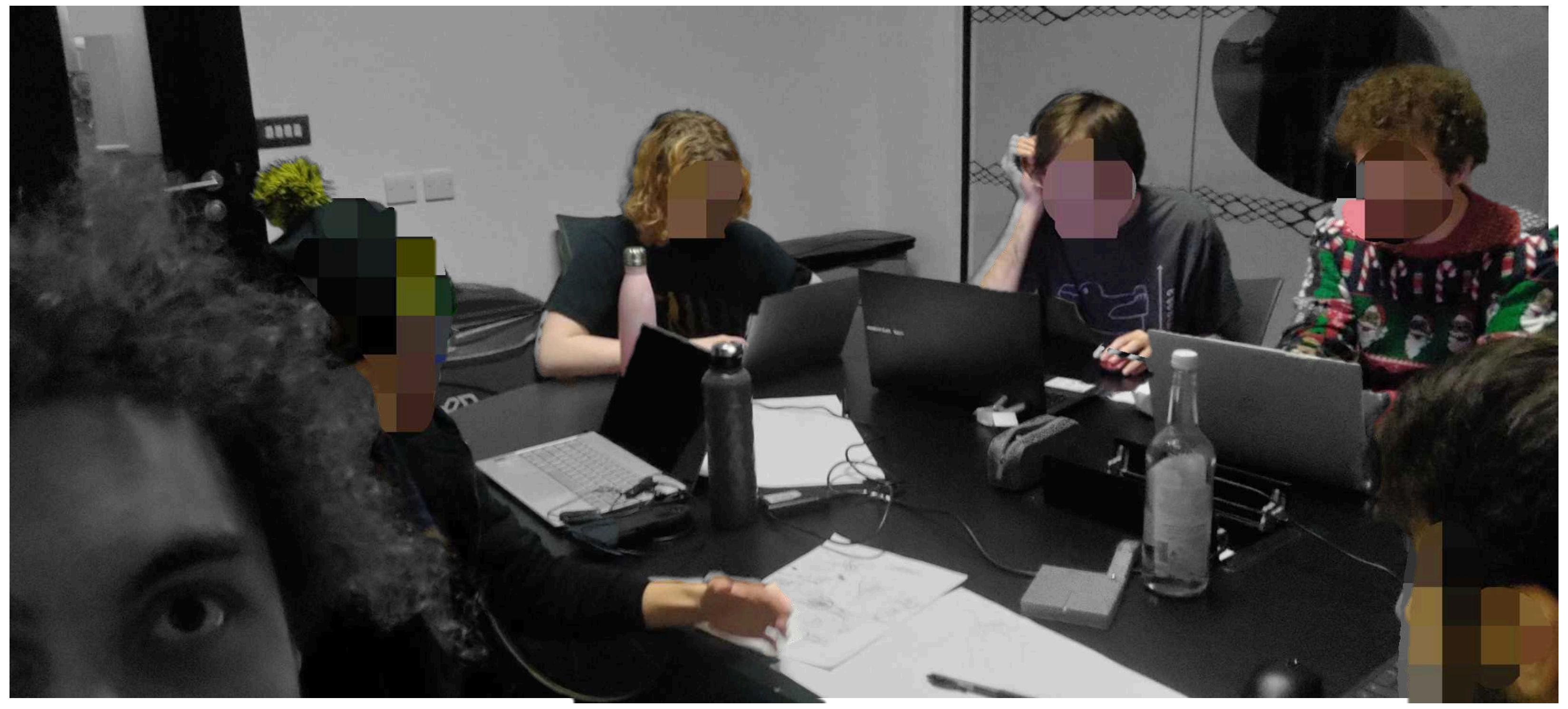
> A patient left in the dark
> No legacy from previous teams
> Team needed recruiting
> Confused industry contacts
> Imminent funding deadlines
> A leader needed to emerge and take responsibility

Challenge accepted



Our patient generously shared his lived experiences with us, which we used to define our requirements. He detailed the uncomfortableness of conventional prosthetics, and his ideas for the arm to have a central weight bearing skeleton.

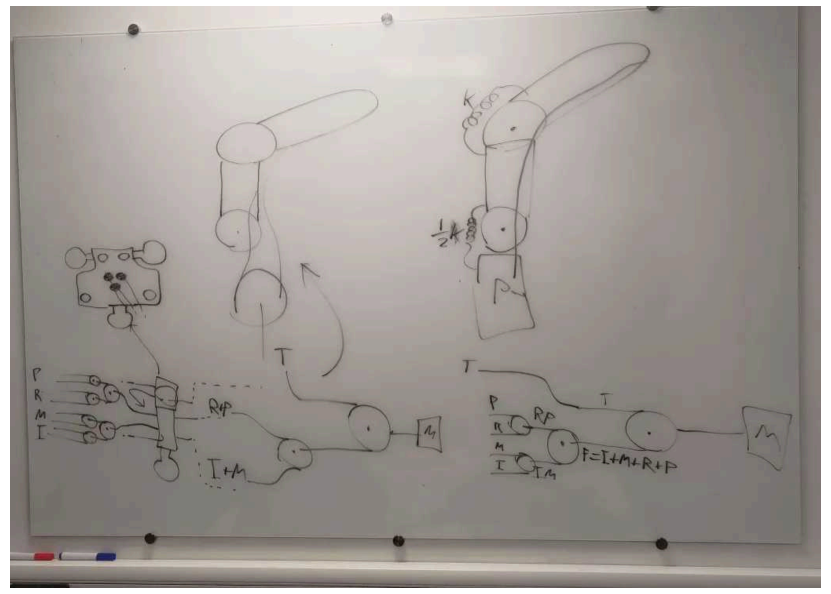
Leading the design process



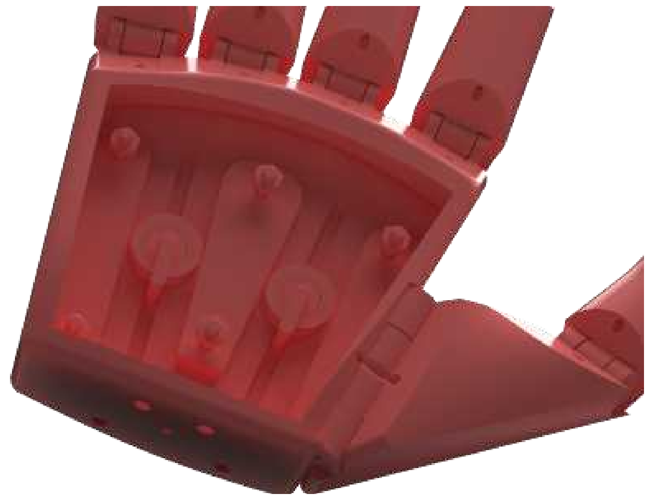
(teammates blurred for privacy)

My role:

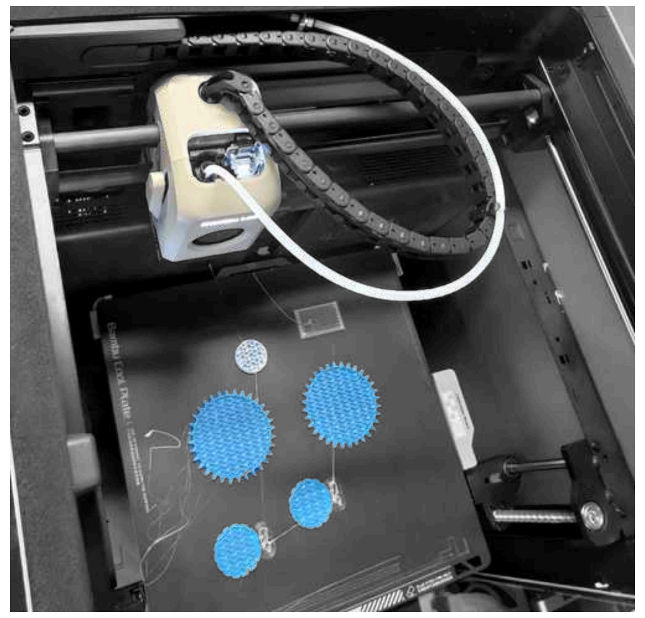
> managing the team and project, facilitating group work
> leading design ideation of wrist and hand mechanisms
> organising and facilitating collaboration with dept of mechanical engineering – for credit design ɔdule in co collaboration with a student-led project (us)
> 3D printing and testing the mechanism



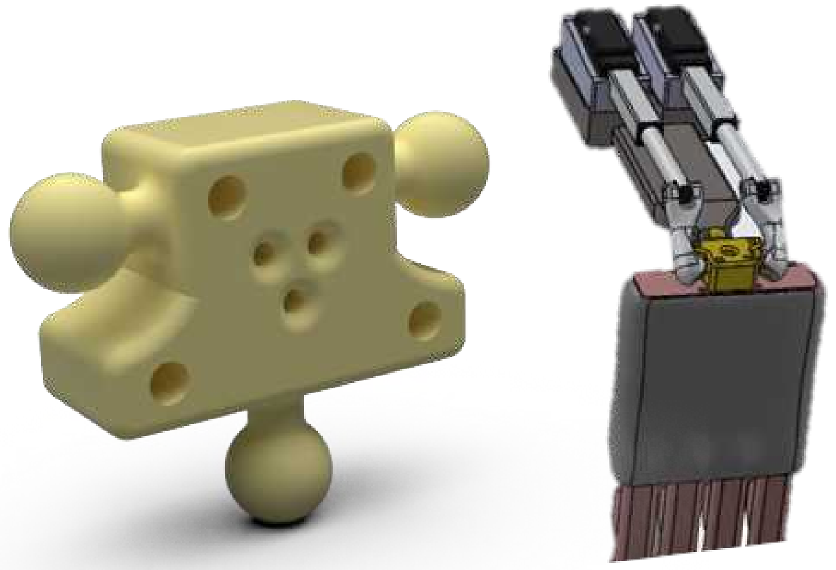
Led brainstorming sessions



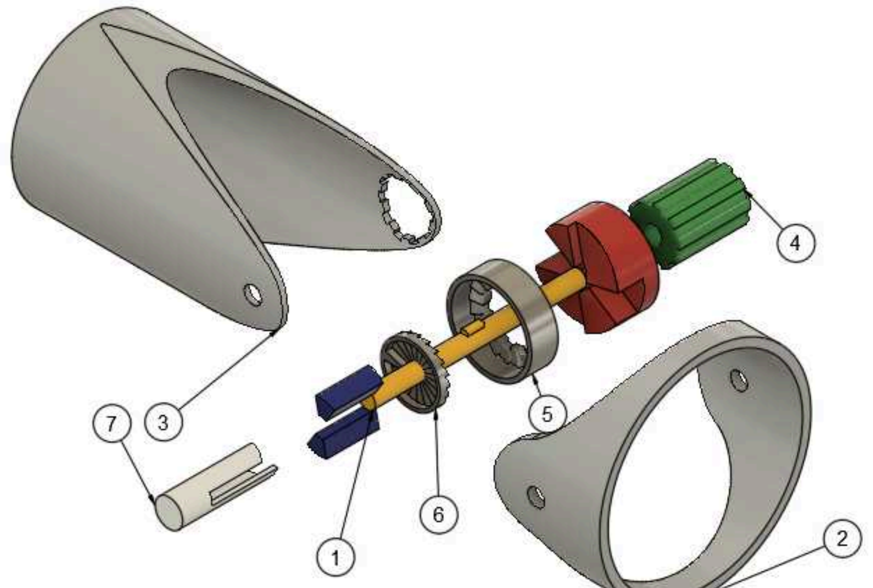
Whippletree pulley mechanism allows hand conformability around objects with only a single motor



Experimented with 3D printing infill patterns and densities



360° dual linear actuator wrist mechanism inspired by teslabot

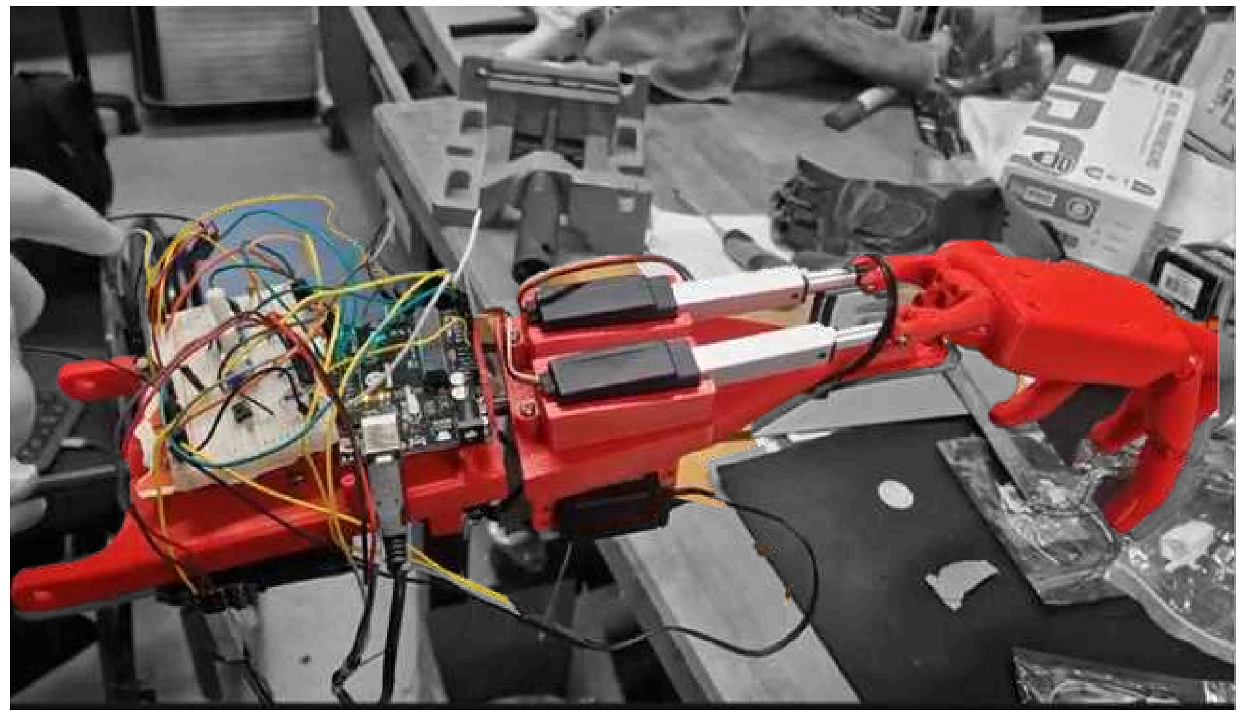


MechEng module collaborators created a locakble elbow

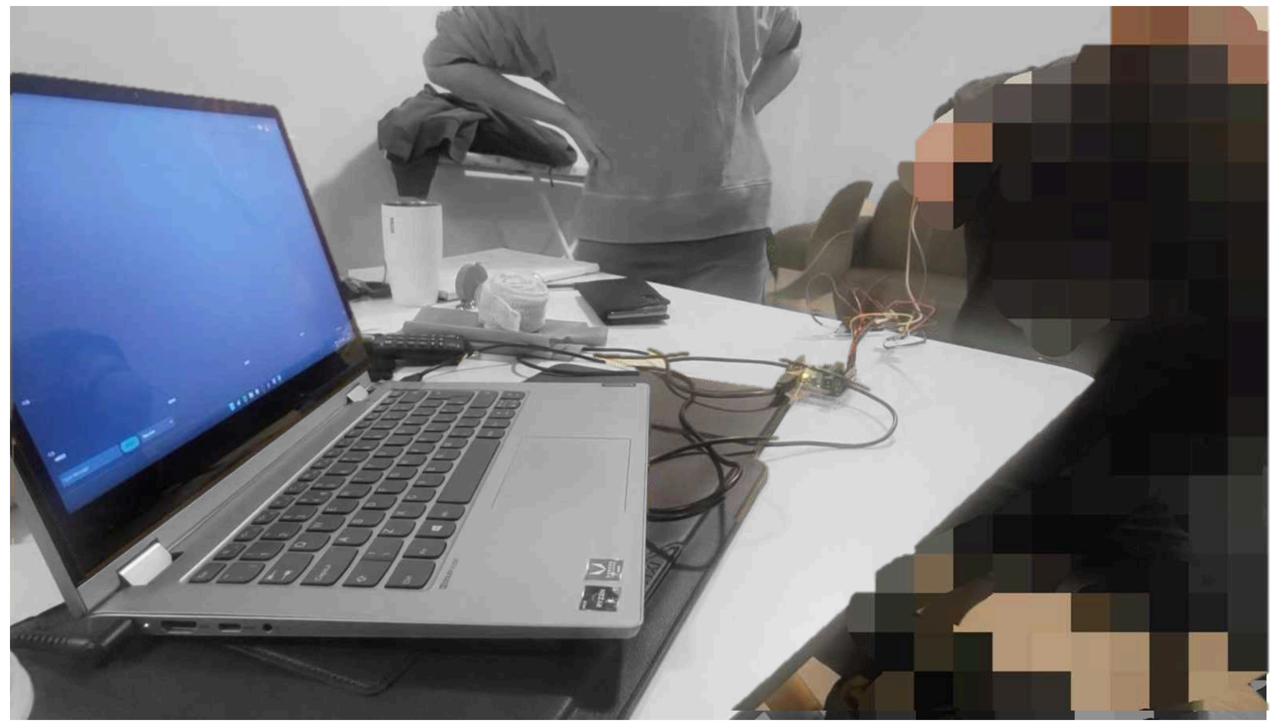
Qualitative testing - wrist mechanism held far more weight than expected

Receiving signals from our patient’s residual limb

was a signfiicant challenge as our patient’s amputation was above elbow. Conventional muscle signal pickup methods were unviable, and the signal was noisy. We trialled a Time Delay Neural Network which had 80% accuracy

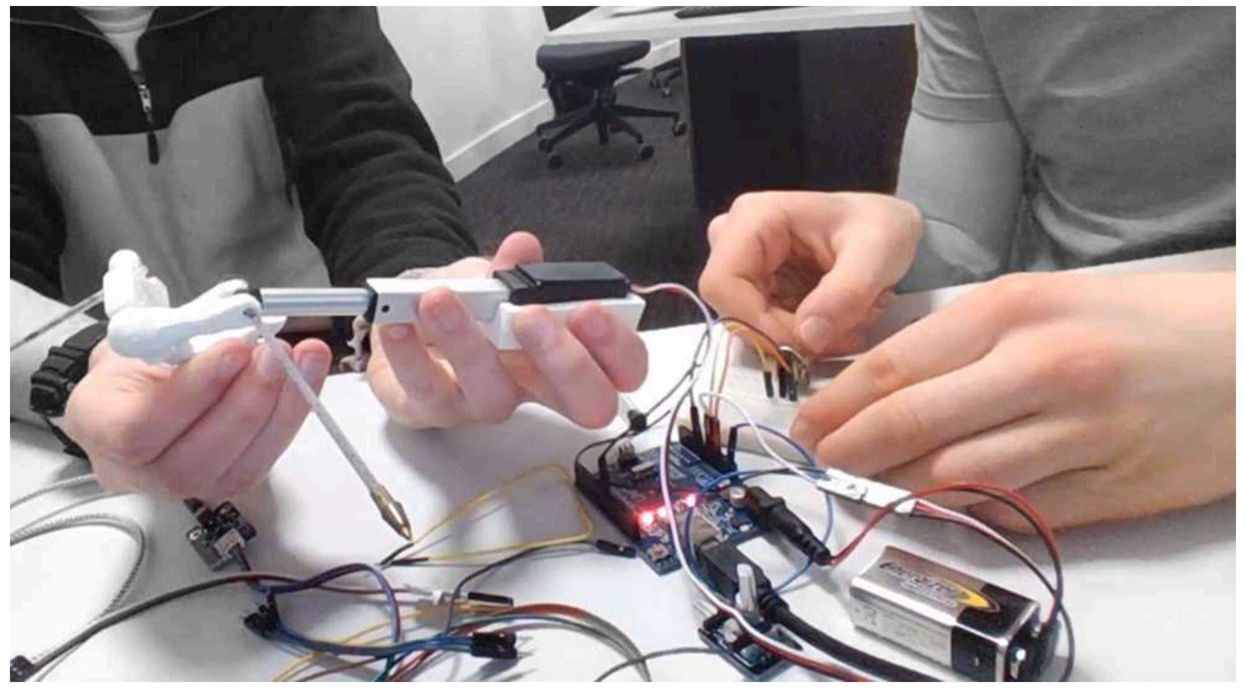


Assembled prototype



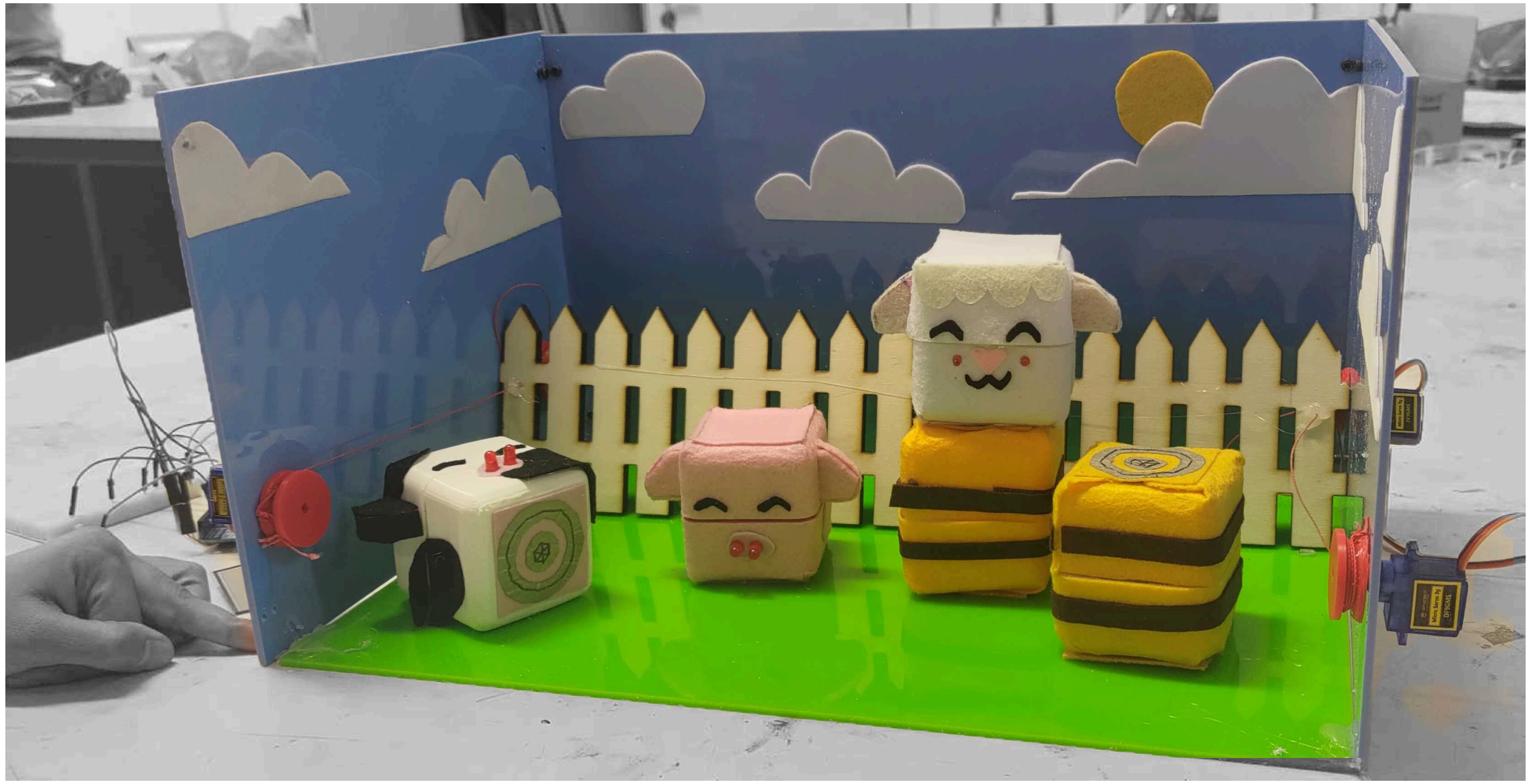
Obtaining training data for a neural network to interpret patient muscle signals

(patient blurred for privacy)



I wrote some arduino code to control the arm manually with as a backup, in case the muscle pickup failed

The groundwork laid during my leadership - including patient, industrial sponsor, and academic relationships; technical foundations; and team structure, continues to drive progress under the current team, towards the goal of delivery to patient.



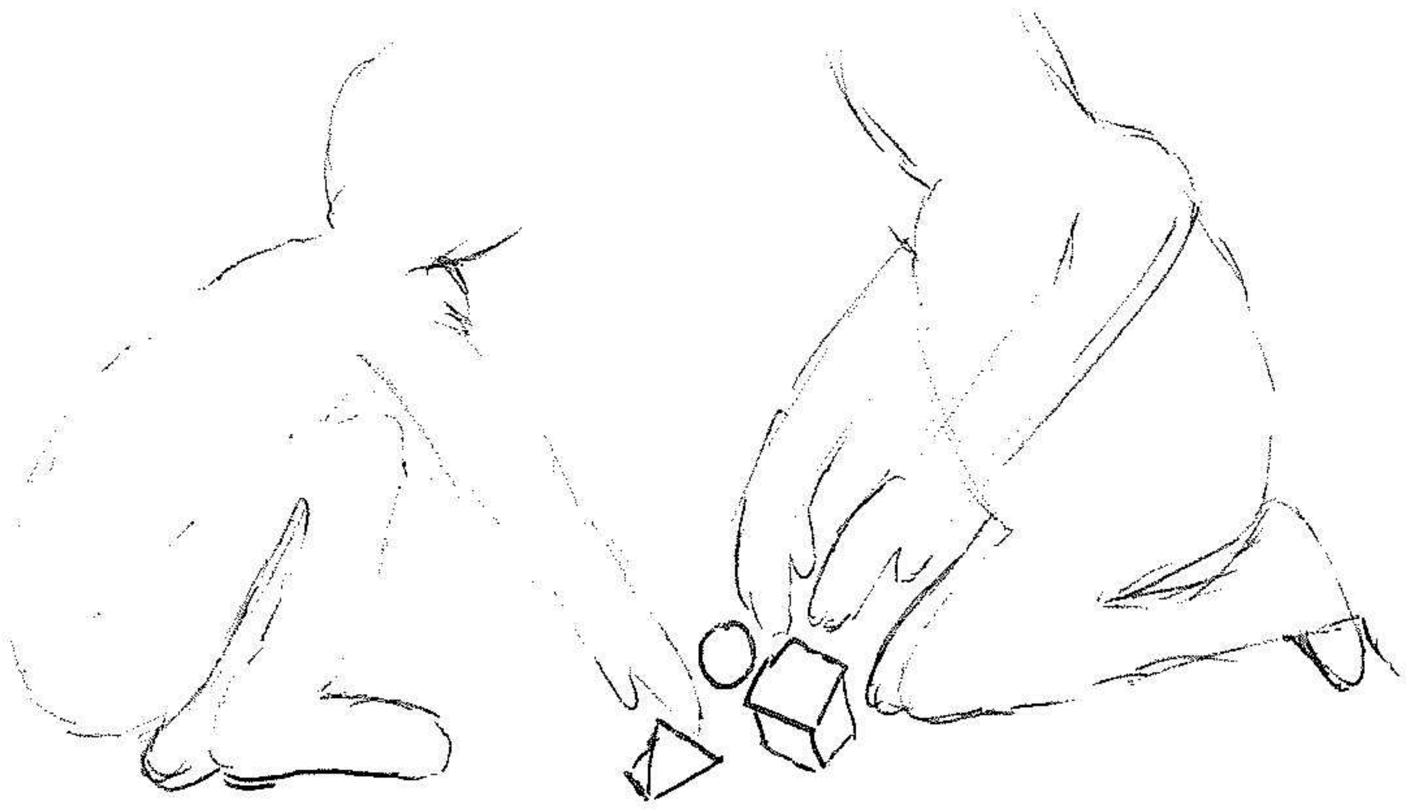
Toys for OI

University hackathon group project: Designing and creating toys for toddlers with Osteogenesis Imperfecta over a weekend

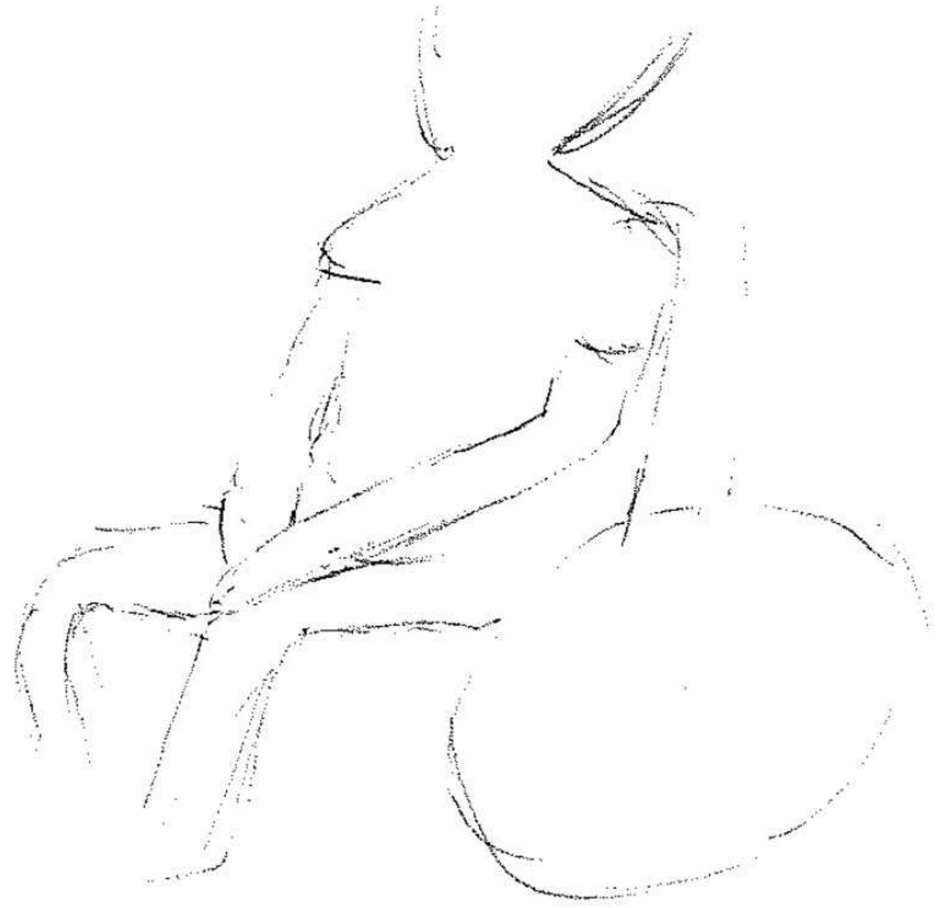
Key skills: CAD, design ideation, rapid prototyping, interviewing users + stakeholders

Group play between children

forms relationships + teaches key skills



But children with severe OI can't play with conventional toys



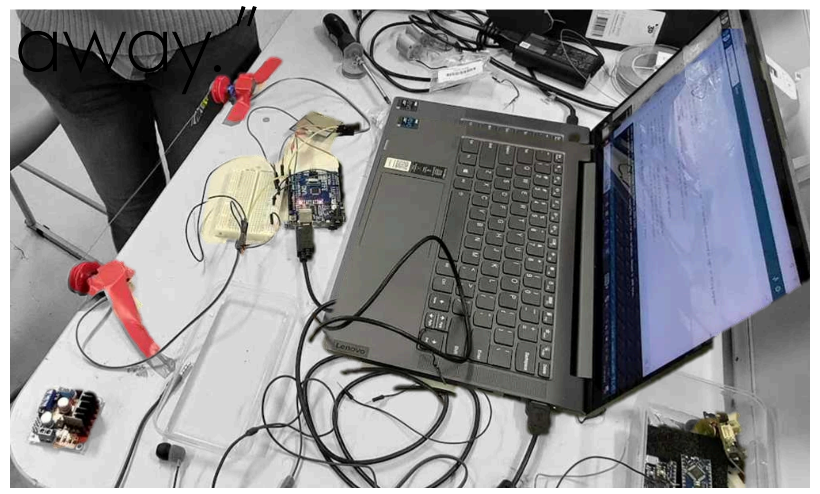
What if toys could be designed for inclusion, facilitating play regardless of ability?

Collaborating with paediatric specialists

We regularly interviewed a paediatric specialist from Sheffield Children's Hospital to understand the children's requirements. Questions and answers from these discussions guided our design process. Each design choice prioritised enabling independent play while ensuring safety.

Q: "Where do common toys create frustration?"

A: "They struggle with mobility, so can't get their toys if they fall far away"



Arduino controlled motorised block return system to bring toys back within reach

Q: "What toys tend to cause injury?"

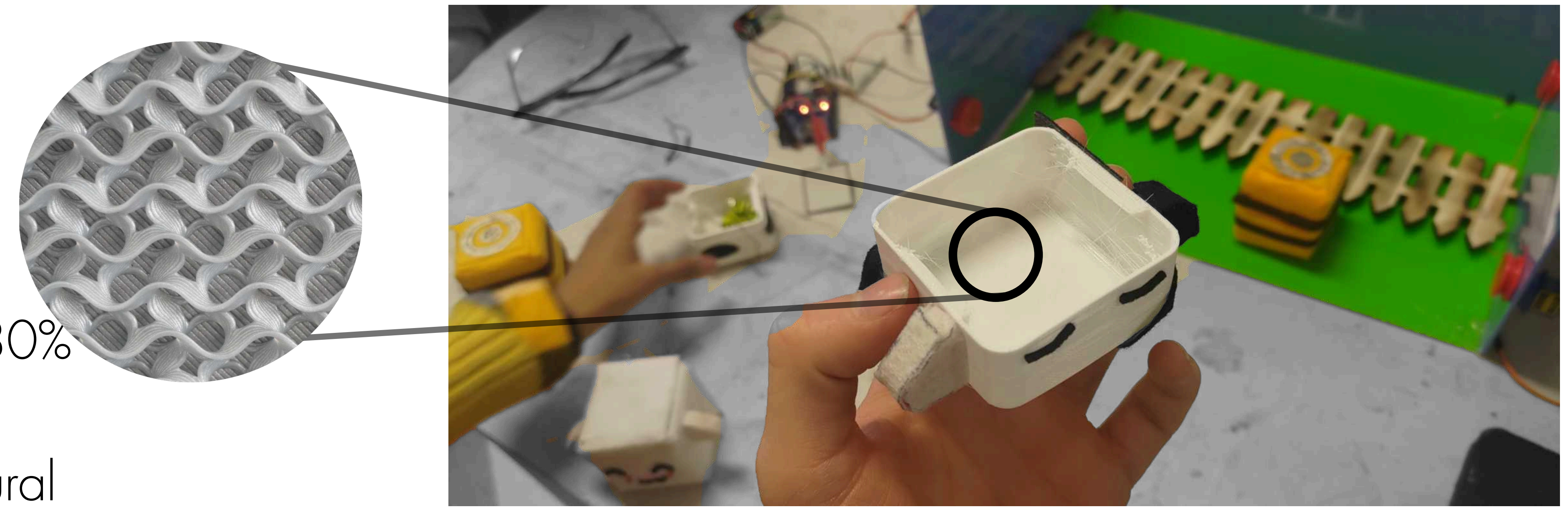
A: "They break their fingers on interactive buttons"

→ Touch sensor activated system eliminates need for physical force

Q: "What prevents them playing with standard toys?"

A: "Even plastic cars are too heavy. They can break their wrists"

3D printing → gyroid infill = 80% lighter while retaining structural integrity

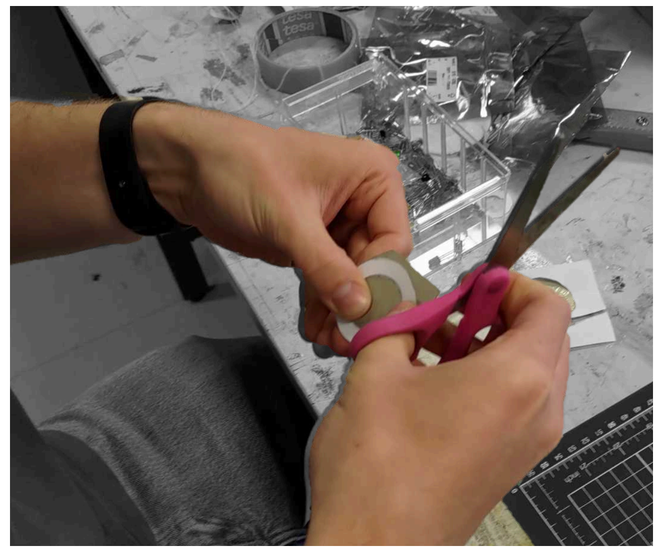


Challenge: speaker and electronics too heavy in each block

Solution: use only the bottom "hay bale" blocks for the speaker and battery

Q: "What do the children love playing with?"

A: "They love seeing interactions, anything they can directly interact with"



Dual textures – furry felt + smooth plastic for sensory appeal

Conductive thread electrical connections, creating interactions between blocks

Challenge: hard wires restrict movement and pose safety risks

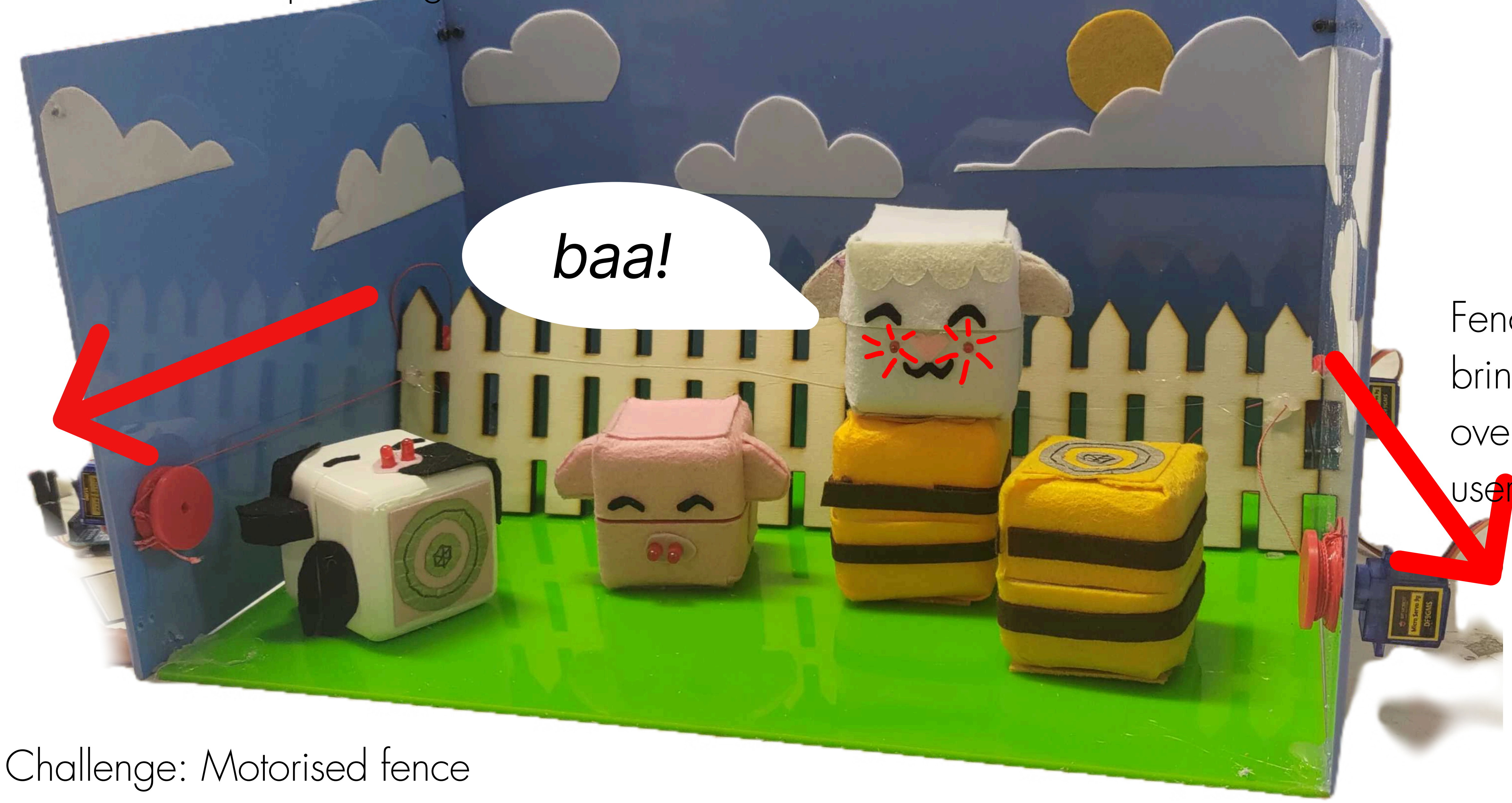
Solution: Soft, flexible conductive thread enables free play while ensuring safety

Designed bespoke clip and tested for firmness – prevents swallowing of batteries

Parent perspective: "We'd love to be able to leave them to play independently without having to worry about constantly supervising them"

Project delivery

Challenge: controlling speed for safety, limited range of rotation of servos
Solutions: use low powered motors, use large pulley and two motors to achieve full pass length



Fence moves to bring knocked over toys back to user

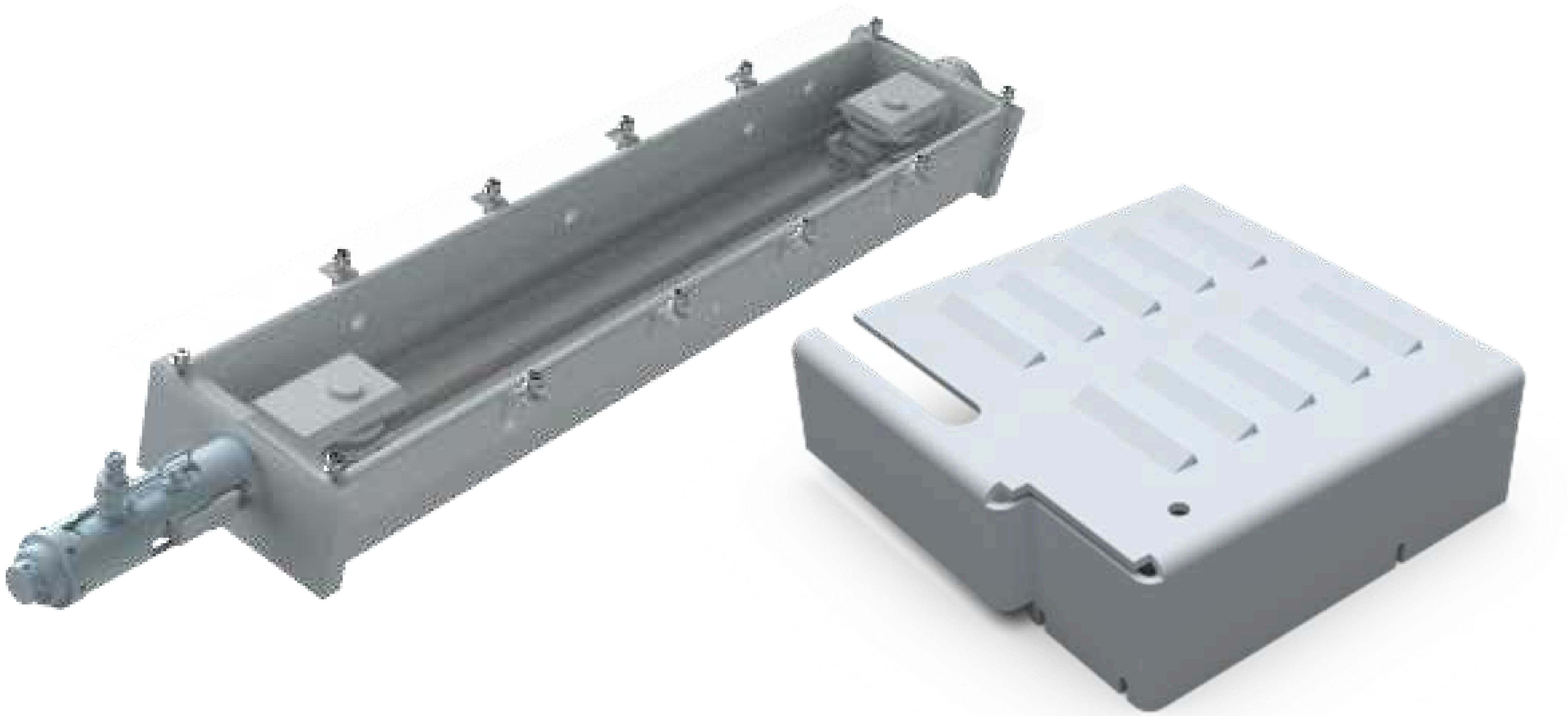
Challenge: Motorised fence pulley string got tangled in transport
Solution: Box in the string in a channel on the walls

Challenge: LEDs needed pressure to make electrical connection to hay bale
Solution: Use small embedded magnets to help align electrical contacts

Challenge: LEDs worked intermittently due to faulty wiring
Solution: redo wiring under less time pressure

Project was presented to Sheffield Children's Hospital, who commended the design. Further development is needed to ensure health and safety standards are met before implementation

(teammate anonymised for privacy)



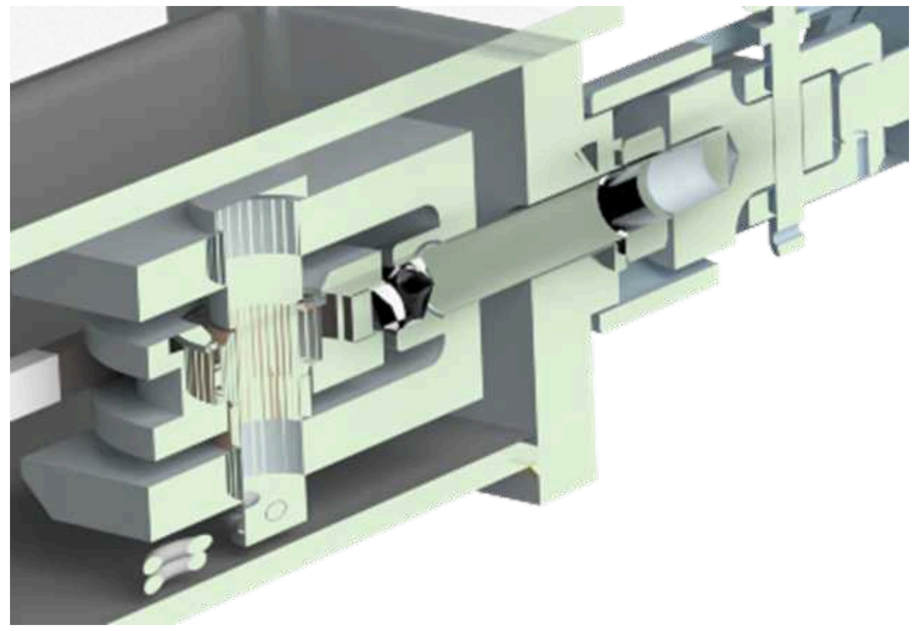
Siemens Healthineers

Paid employment: R&D intern for MRI magnet technology
Key skills: Computer aided design, finite element analysis, design for manufacture, mechanical engineering, materials analysis

On critical path

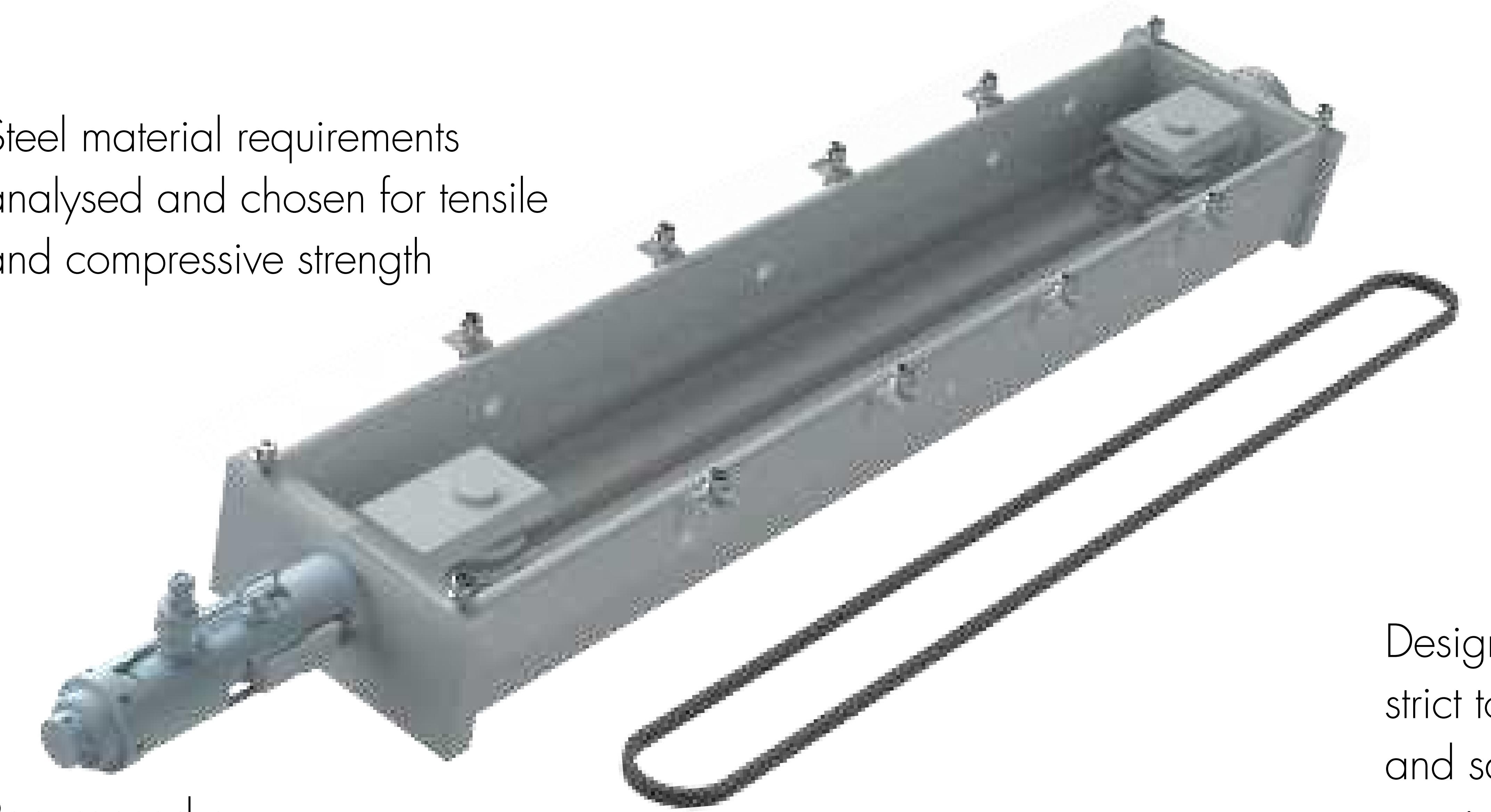
for the design of Siemens' new MRI magnet, working within Siemens R&D team I was tasked with creating a test rig for a novel suspension system

Iterated design for use stresses based on FE simulation data and thread stripping calculations



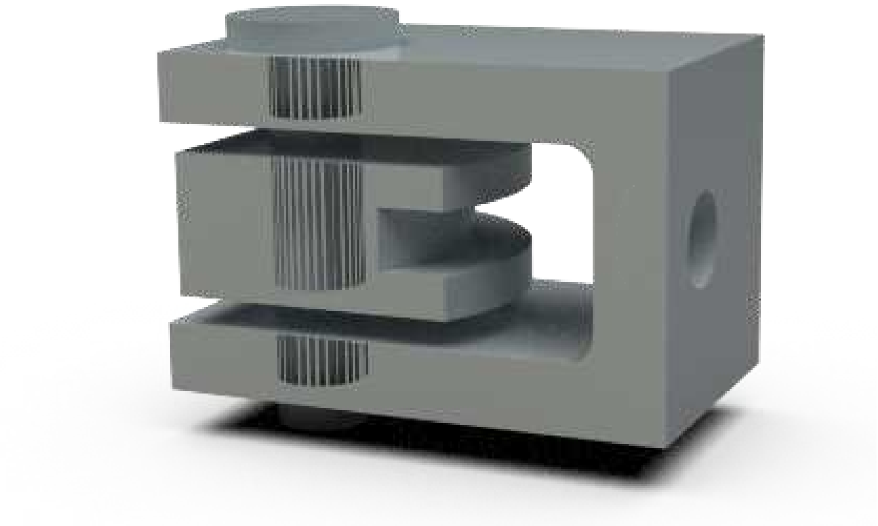
Safety critical thick polycarbonate cover to protect from shards of fractured suspension

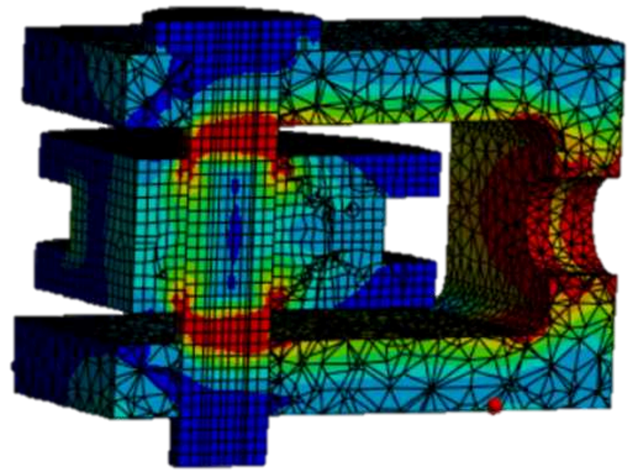
Steel material requirements analysed and chosen for tensile and compressive strength



Repurposed a discontinued tensioner for sustinaability

Understanding the materials of the suspension was crucial to design for it's expected failure mode



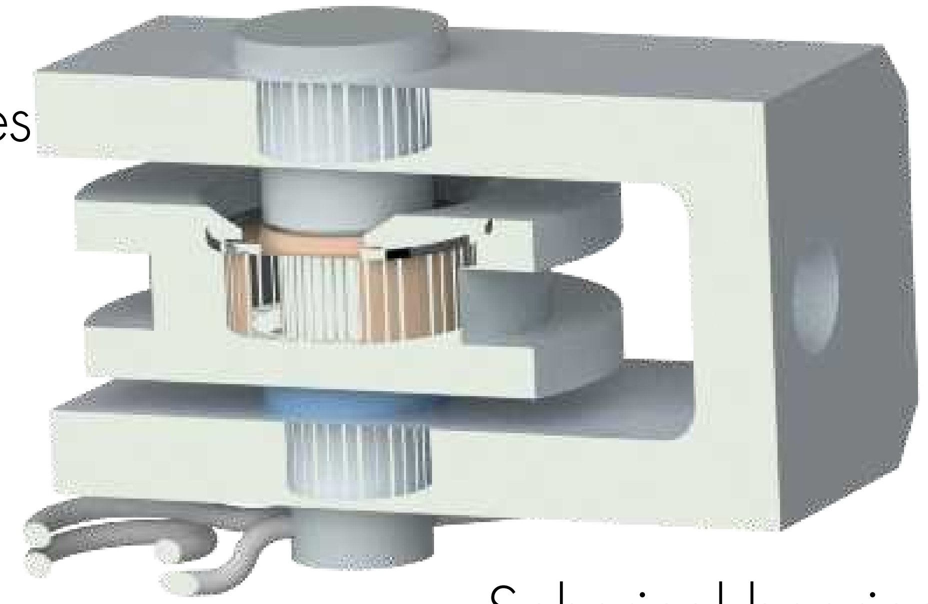


FE analysis showed stress hotspots so I redesigned the assembly

Thicker clevice pin

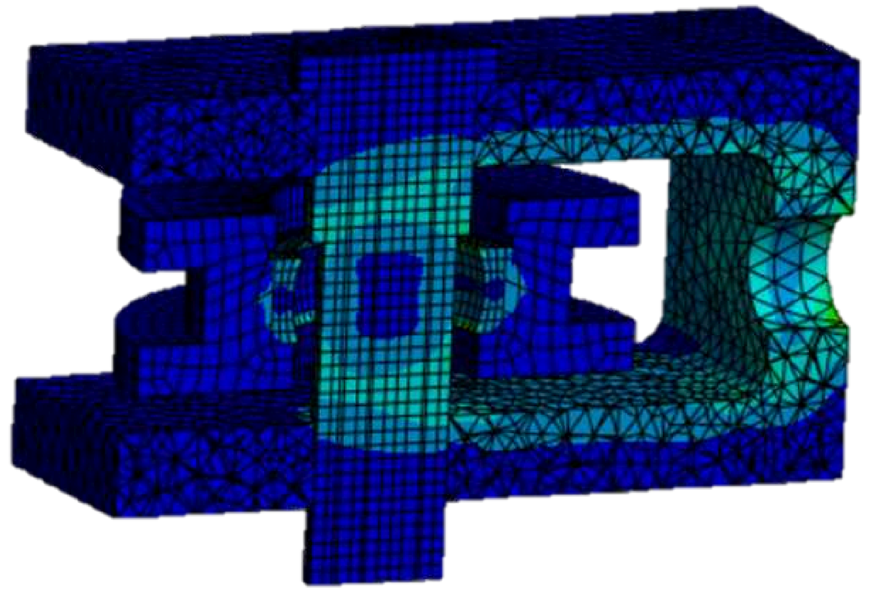
Chamfered edges for ease of assembly

Designed to strict tolerances and safety requirements



Circlips and R-clips to keep components secure

Spherical bearing to allow for bobbin rotation

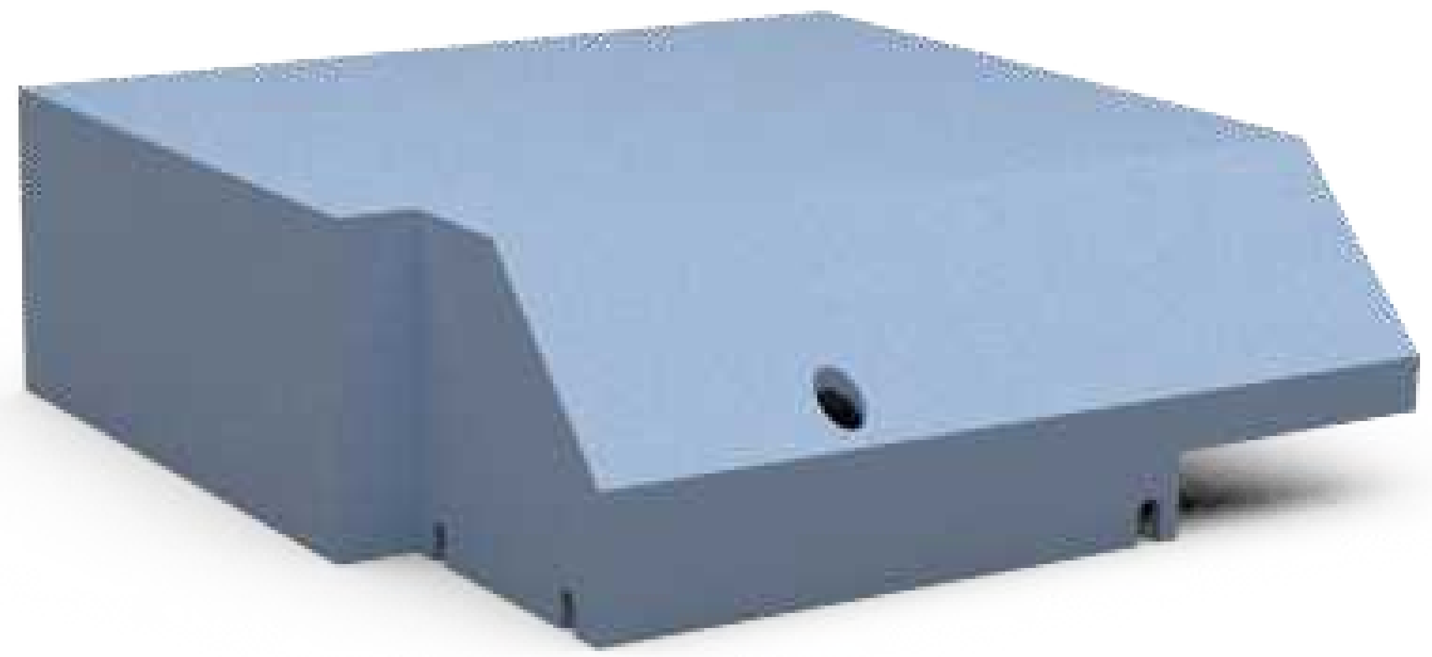


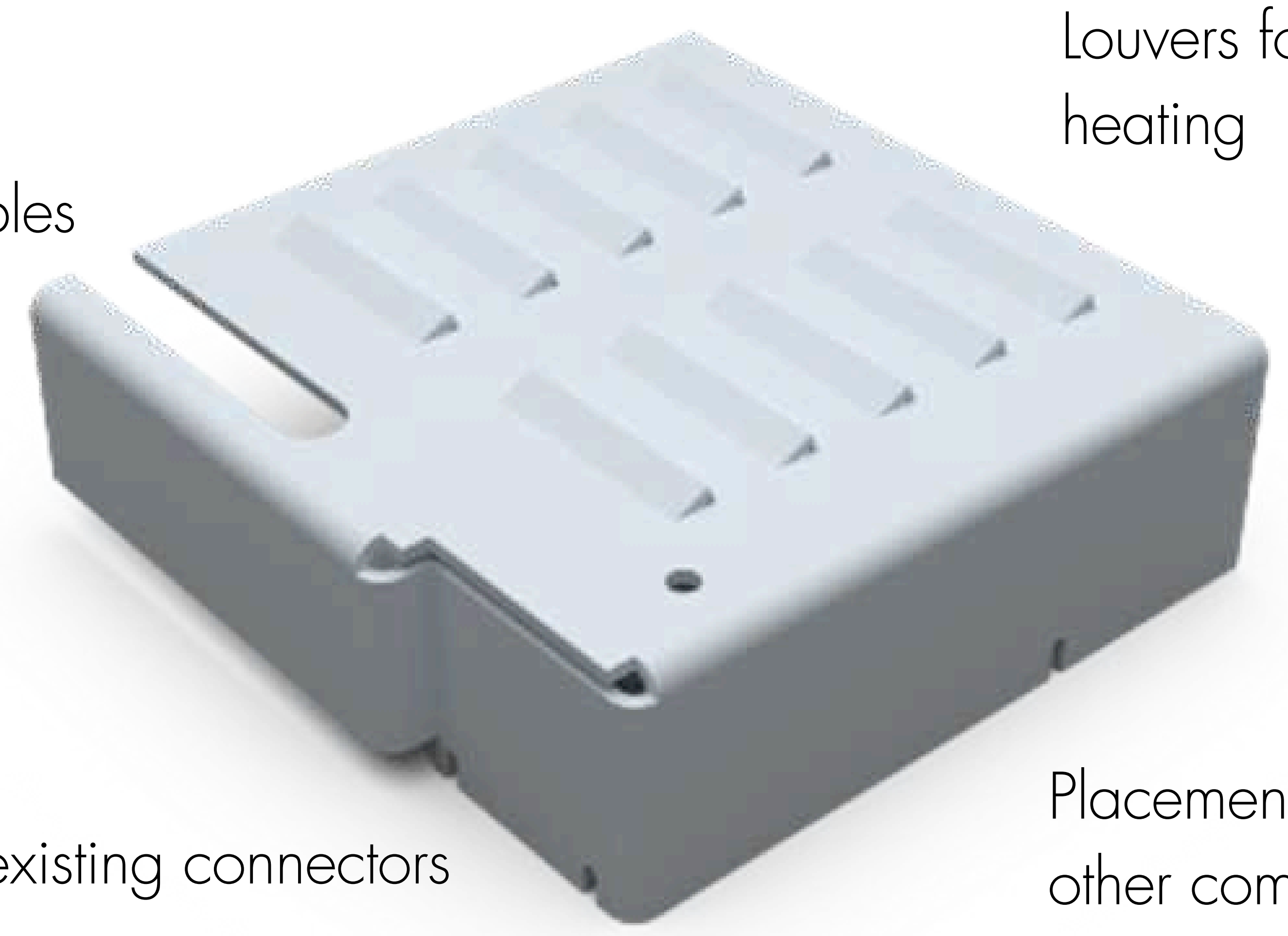
Stresses within requirements

Fulfilling dependencies

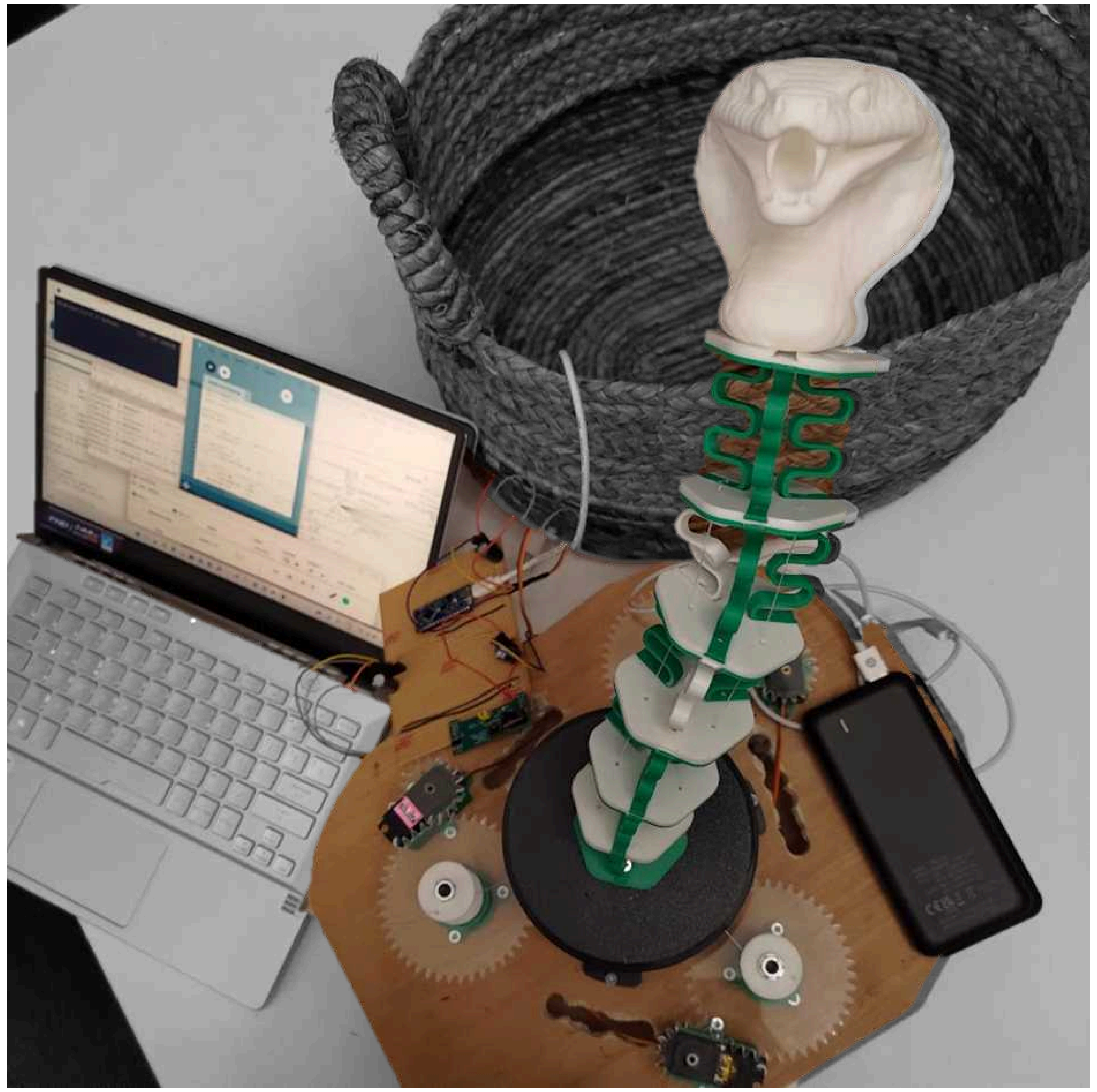
asked of us by the electronics team – a safety critical cover to protect MRI maintenance from the massive currents flowing through devices on the magnet.

Identifying high stress from the cover being leant on, I proposed a cover double the thickness than previous iterations, and made of polycarbonate rather than polypropylene, to give the flexural strength needed





Suggesting sheet bending saved the inflexibility and expense of injection moulding (£30 – 40,000 typical cost for a steel mould). Reached out to suppliers to secure manufacturing process.



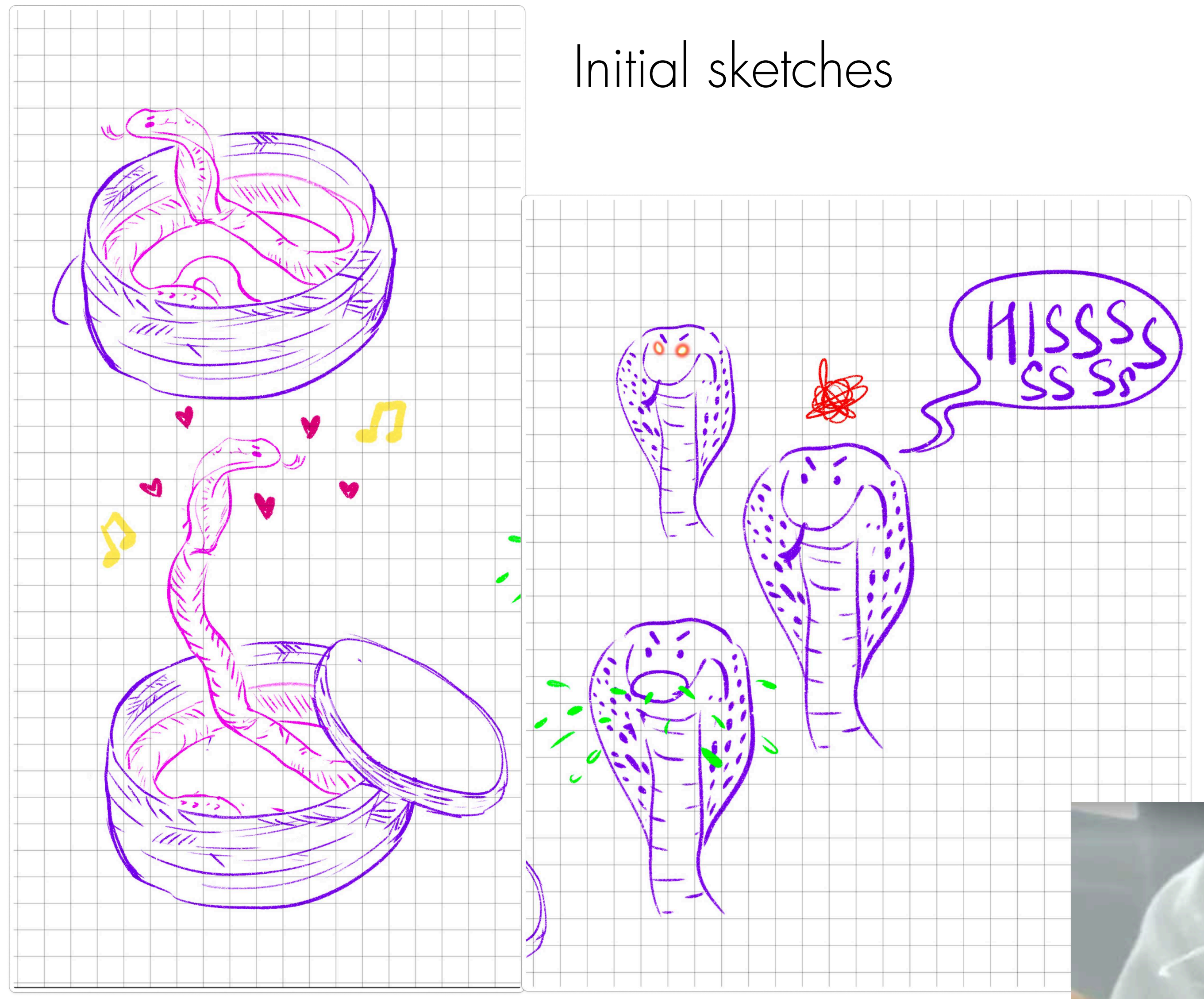
Fluffy the snake

Cyber Physical Systems module on machine learning

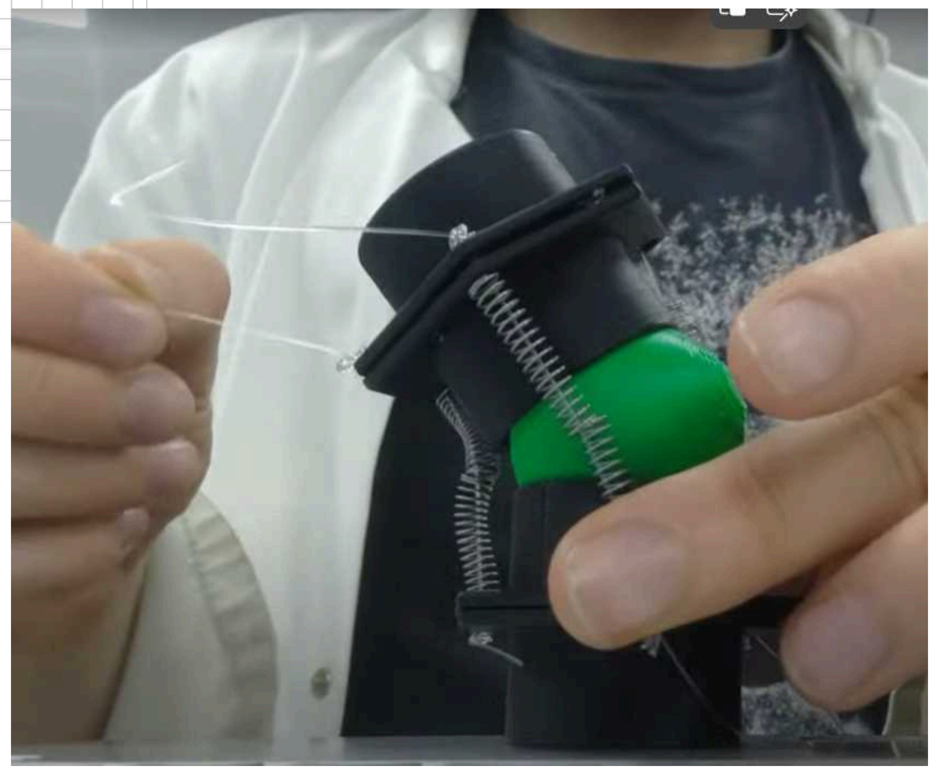
Skills learned: Embedded ML, Arduino, compliant mechanisms,

Cyber physical systems

A 3 person module for the Innovation Design Engineering course. The brief: to create an interesting, working mechanical application of machine learning. Asking the question "what if instead of us judging the machines, they could judge us?" we decided to create a snake robot to be "charmed" out of a basket.

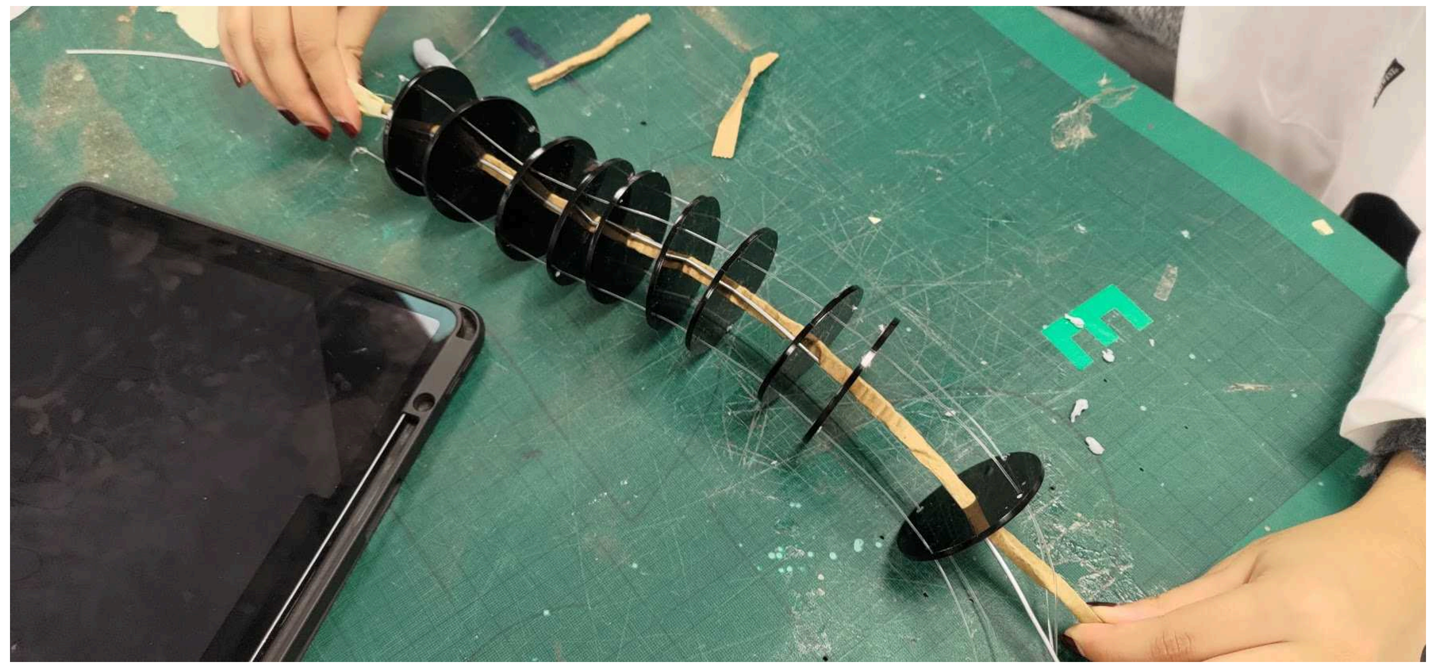


Initial sketches



A socket - ball - socket system was trialled, but was too fiddly to work and needed difficult spring configuration

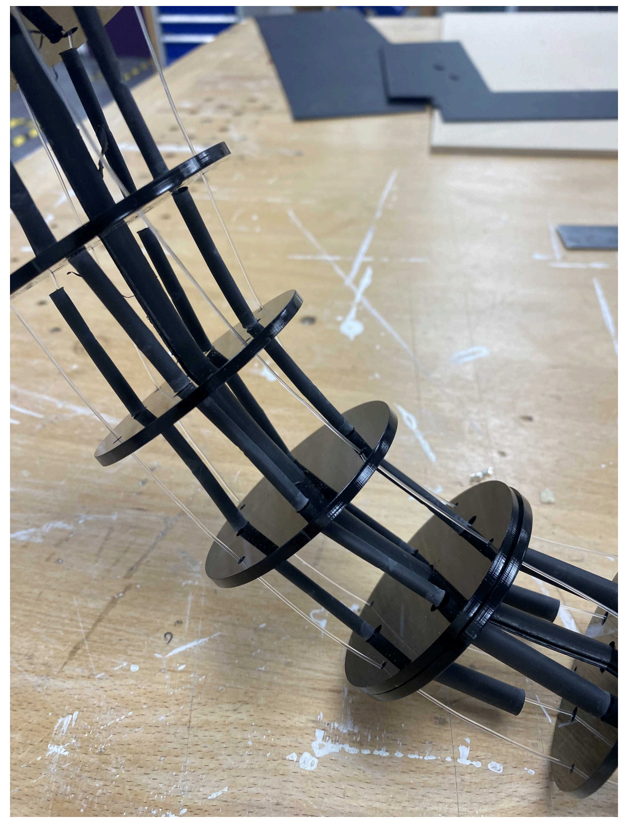
Experimenting with a continuum robot mechanism



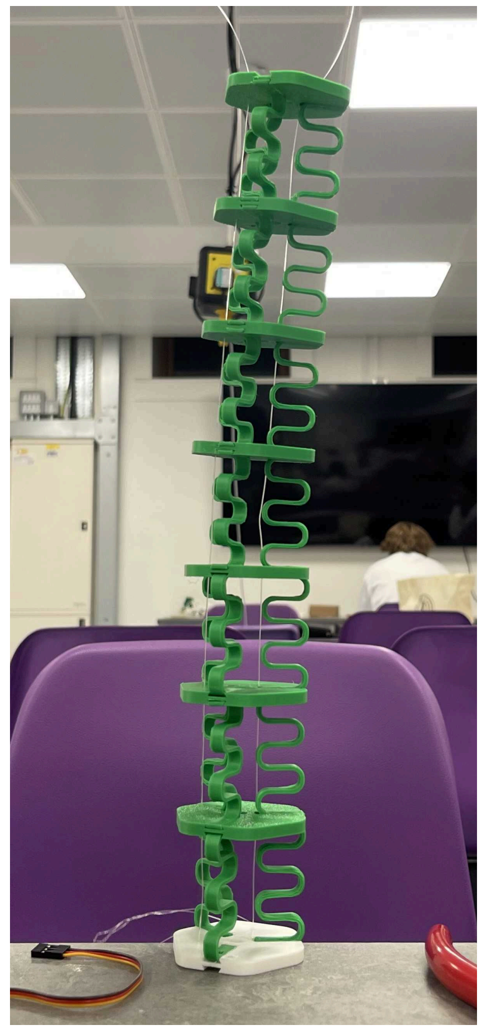
We realised the importance of structural rigidity, while keeping a degree of compliance

Developing the robot

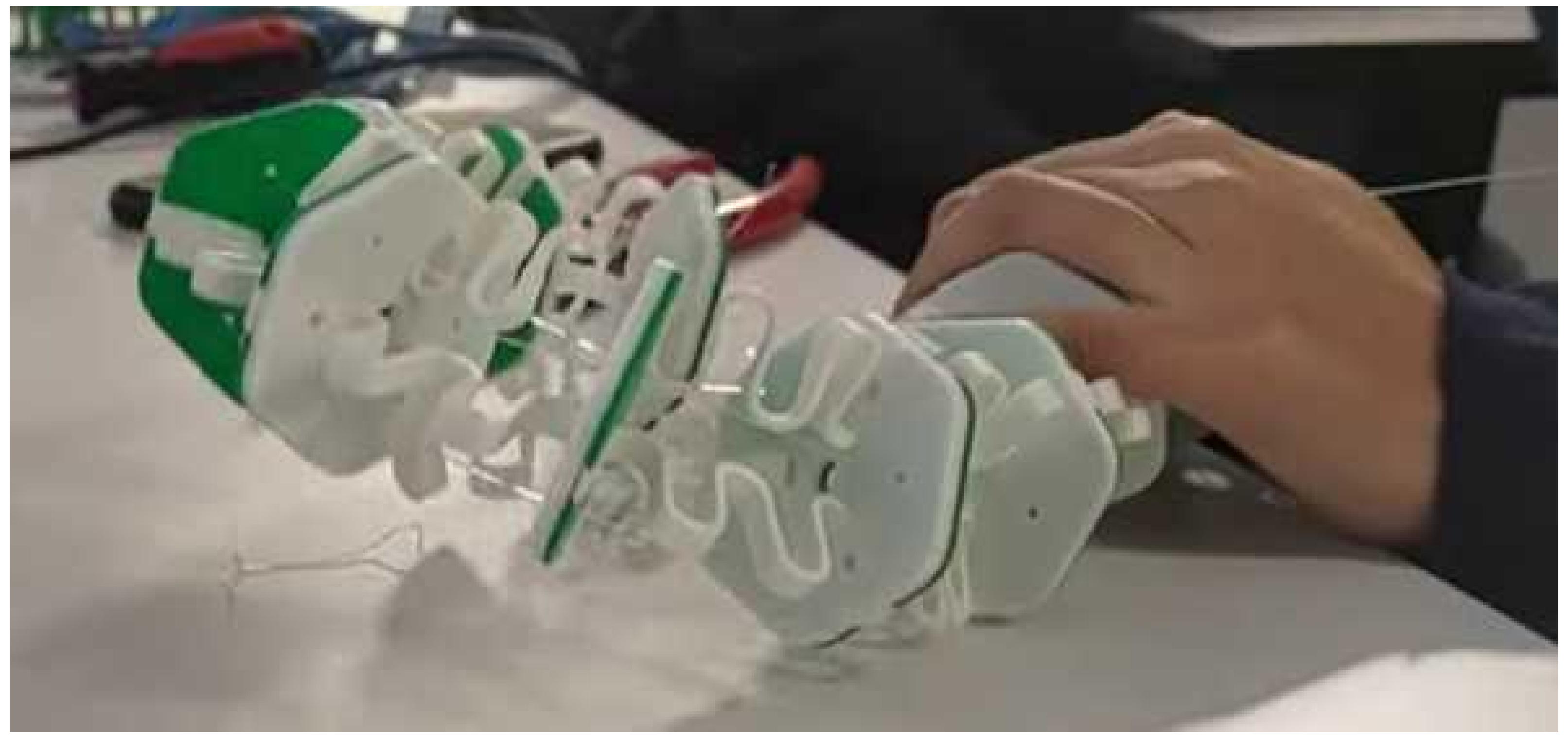
We developed the continuum robot, iterating on various compliant springs via 3D printed TPU and PLA. We were constrained to a 10W (5v 2A) power supply



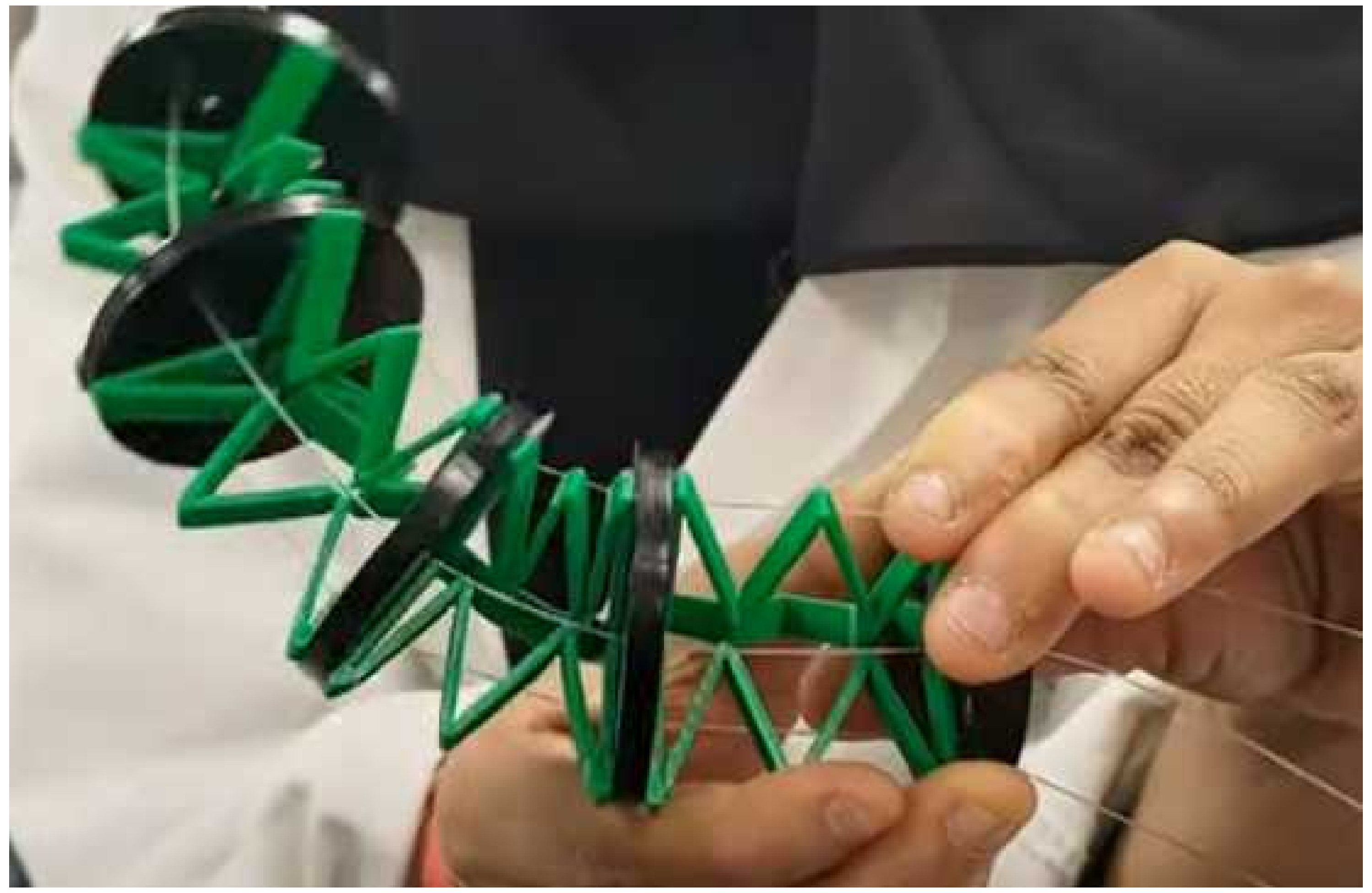
A tendon and sheath system was trialled but sheaths were too flimsy to be useful



Smoothing the bends was better, but just PLA was too rigid



Plain TPU was too compliant, and we struggled to get the "rising up" motion we were looking for with the power limitation - torque requirement was too high



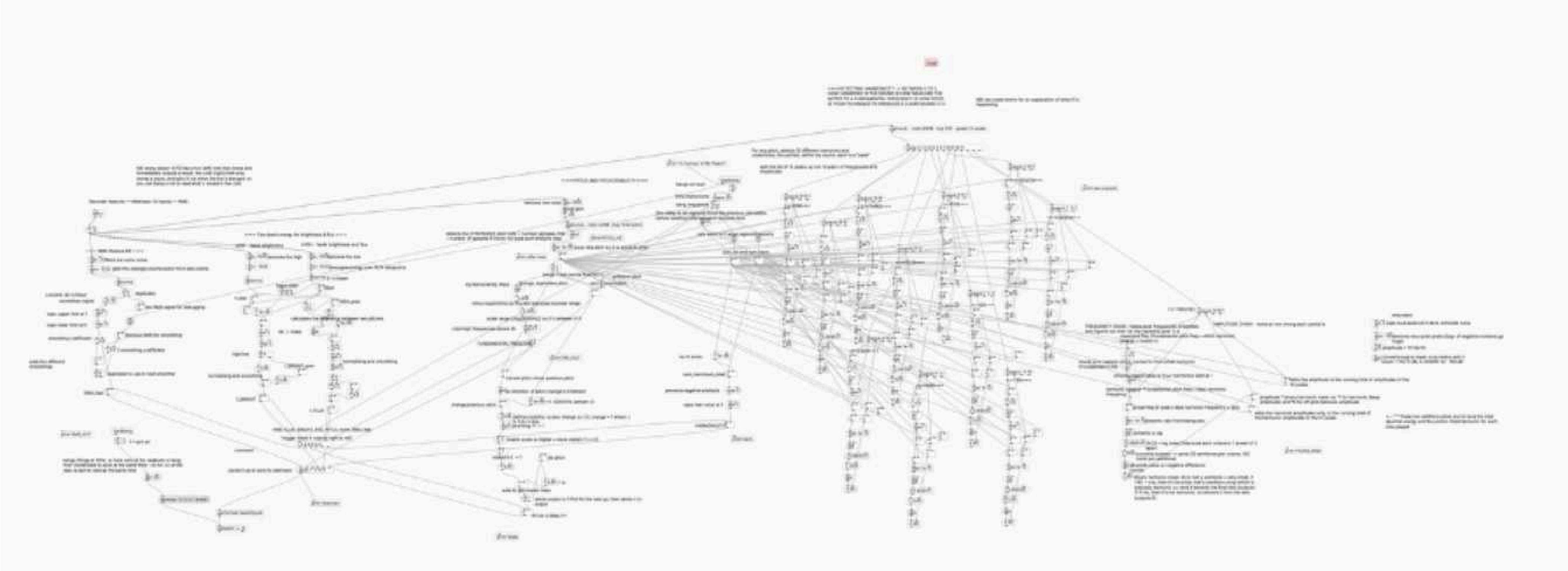
The first compliant springs had sharp bends that broke

We had to settle on a permanently upright position, with a mix of TPU and PLA, and with the music simply making the snake "dance"

To judge the playing

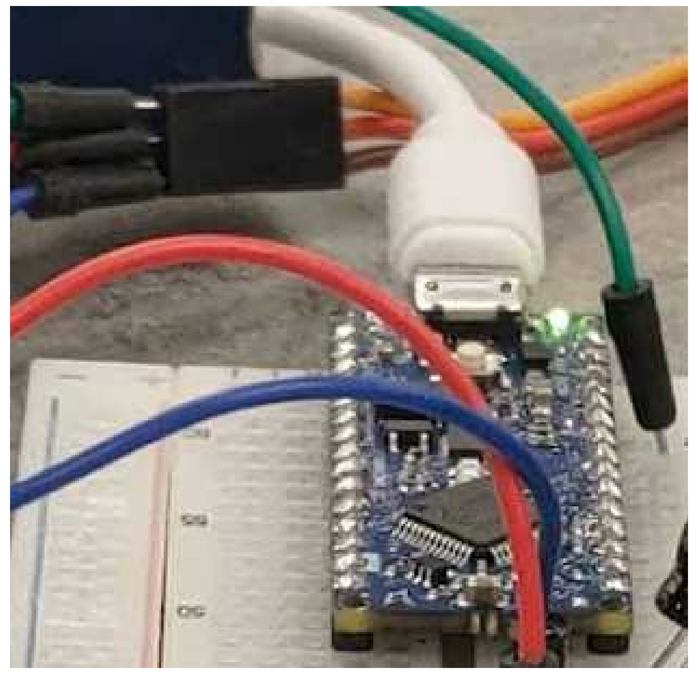
6 qualities of the sound were extracted: brightness, pitch, pitch fluctuation, general waveform shape change, and harmonicity. These numbers could then be fed into wekinator for it's judgement in real time

Sound in

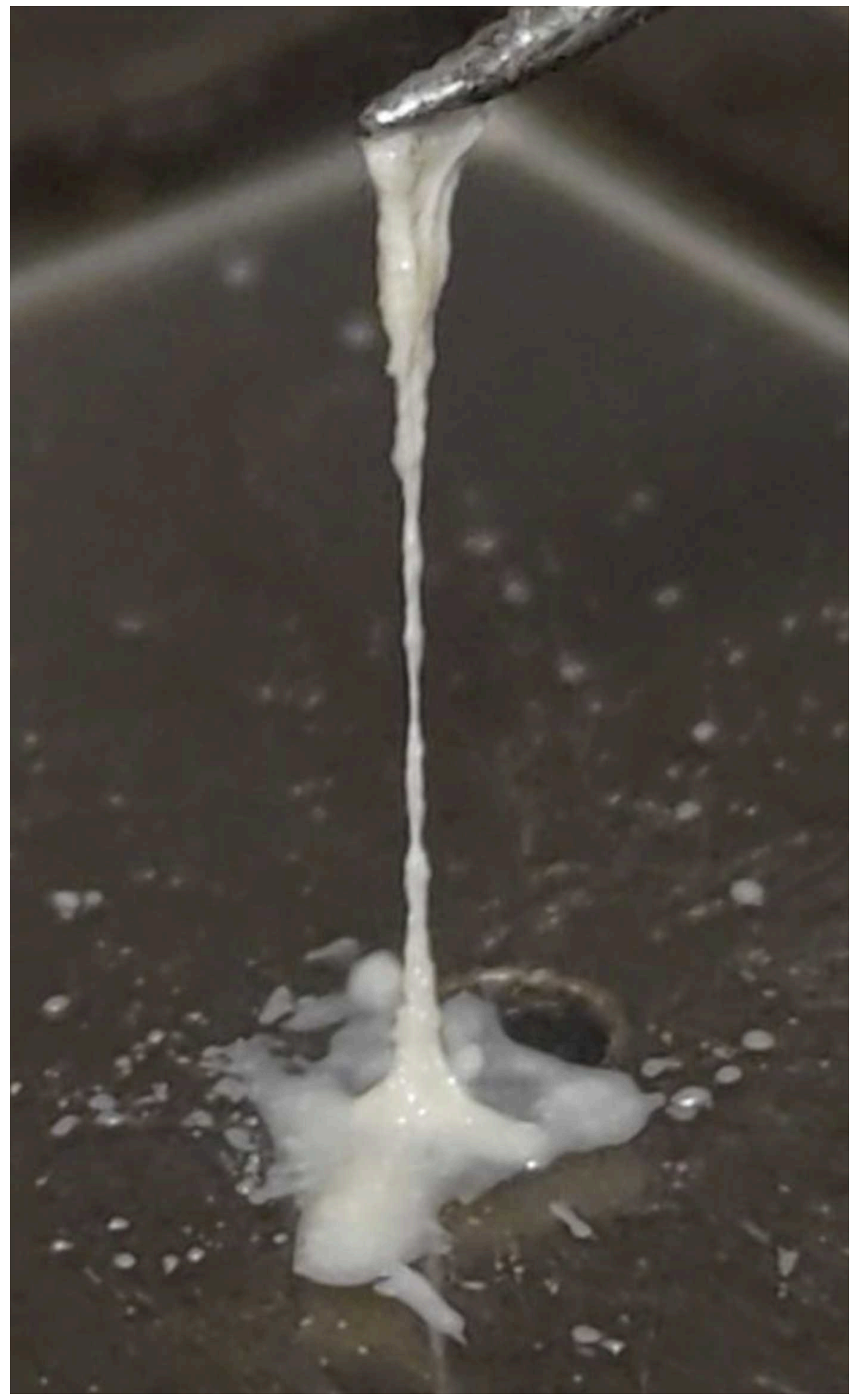


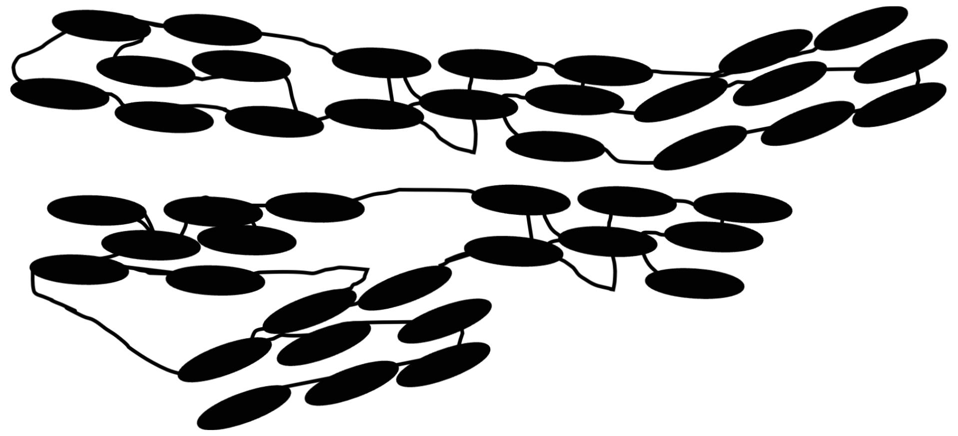
I wrote a puredata script to process the data and extract 6 numbers for wekinator to process

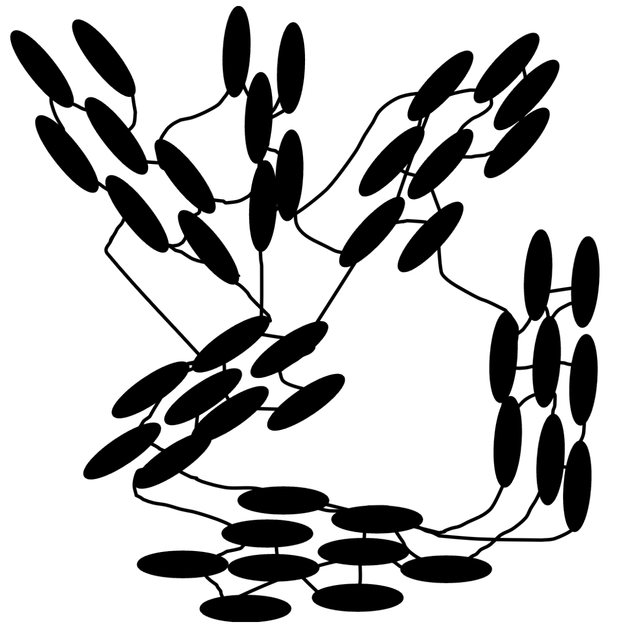
Wekinator machine learning takes 6 inputs, spits out three outputs - good playing, bad playing, background noise

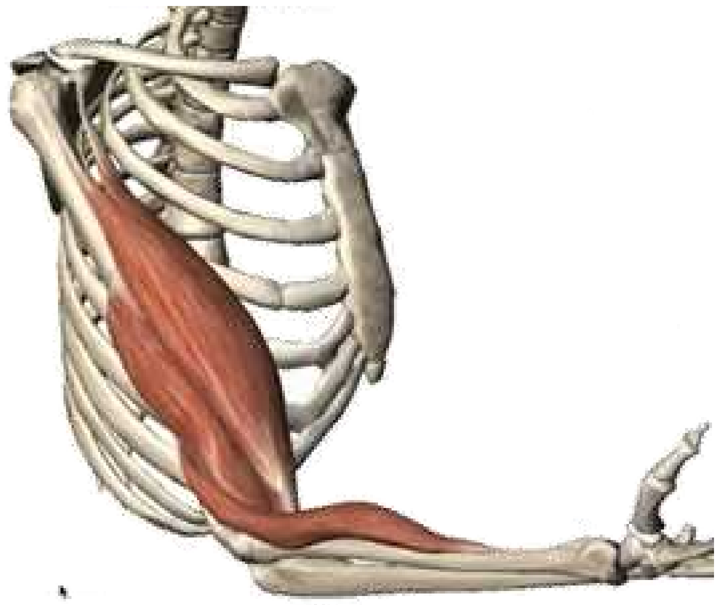


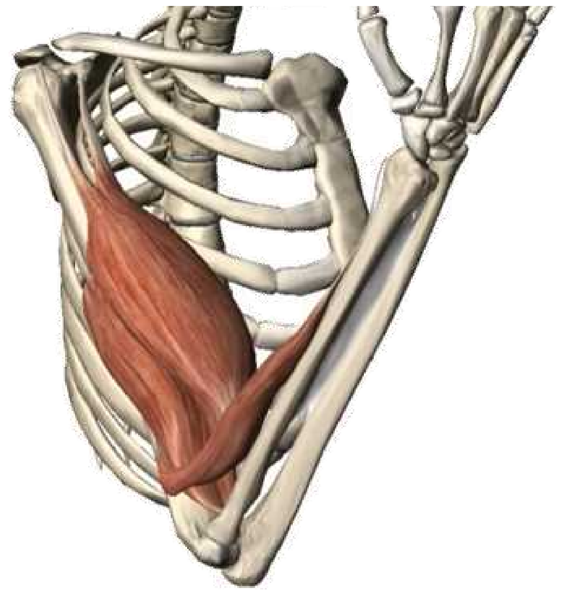
The realtime outcome is fed to arduino via processing











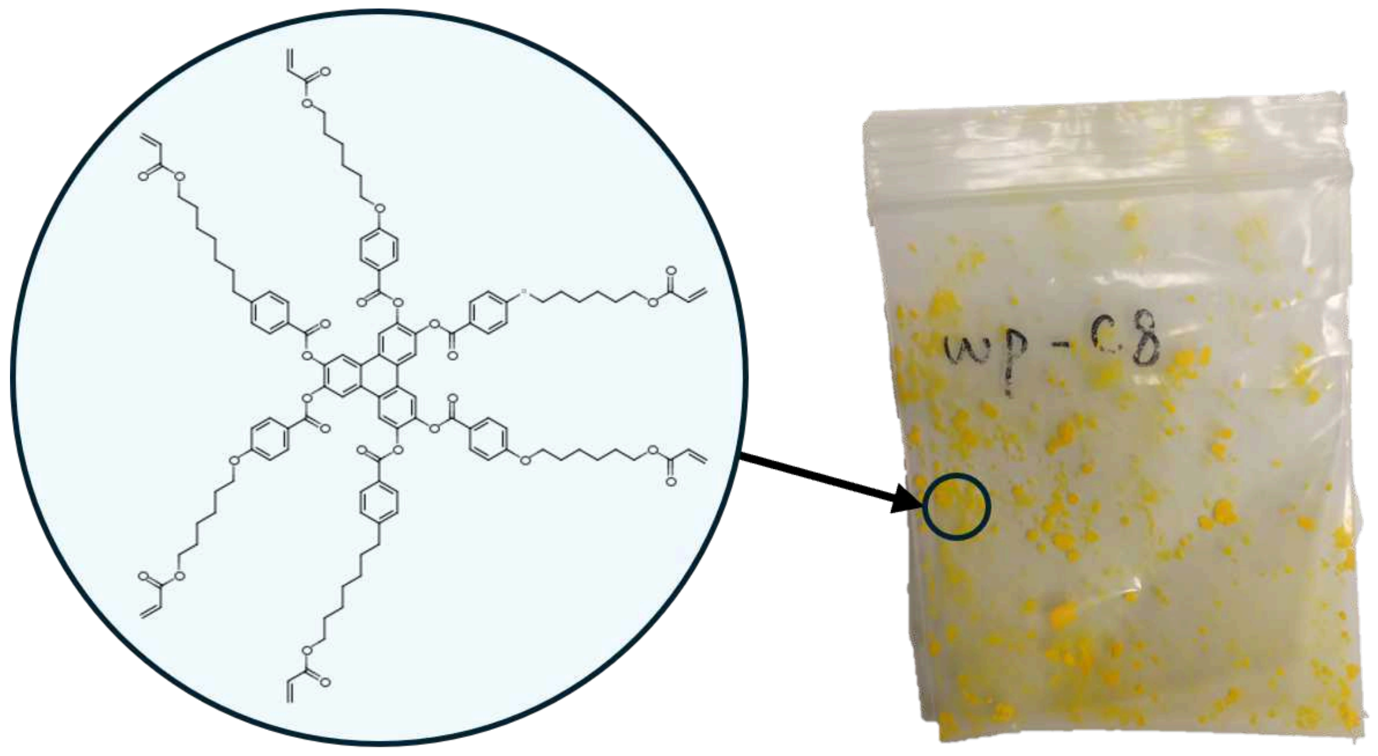
Searching for synthetic muscles

Undergraduate dissertation: exploring novel liquid crystal elastomers as synthetic muscle materials

Key skills: designing fabrication methods, microstructure engineering, executing and analysing DSC, XRD, POM characterisation, analytical thinking in unfamiliar contexts

Liquid crystal elastomers

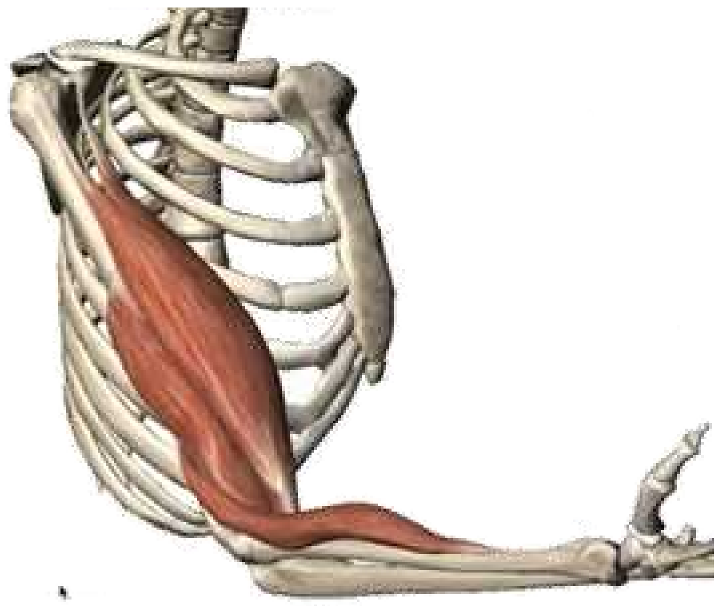
(LCEs) are a new type of material, made of liquid crystal molecules in an elastomer network. Due to conflict between these materials, temperature responsive shape changing properties emerge when the liquid crystals transition between states. The transition's reversibility is unique. Control of this transition can yield soft motorisation, with potential for unrealised biological and/or small scale applications

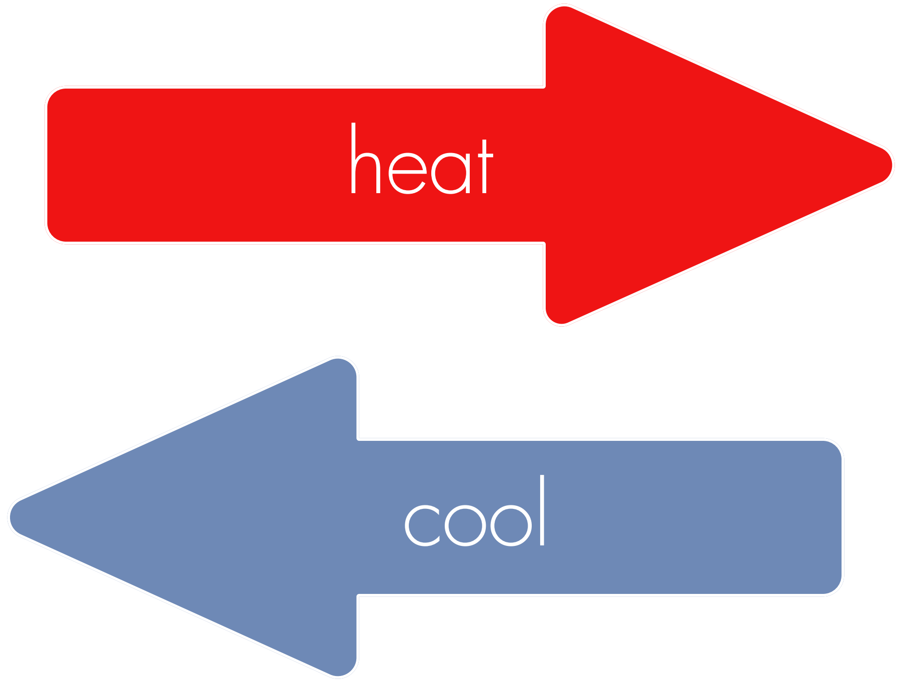


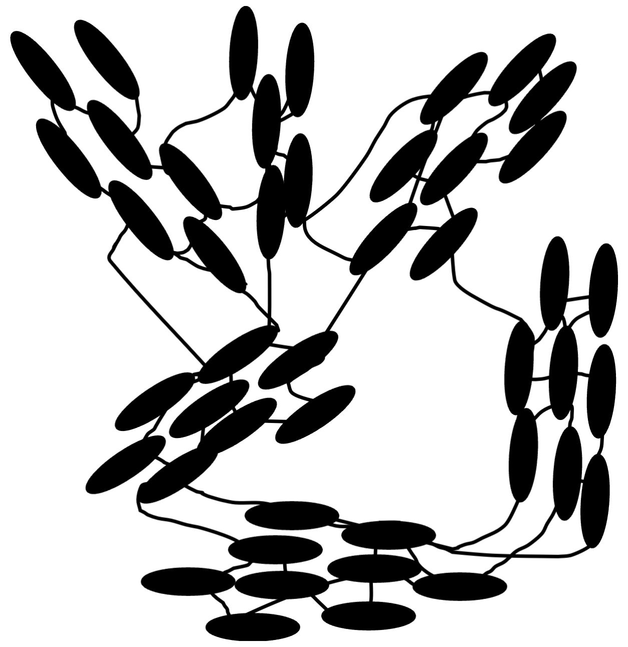
Chemistry of one of our samples

Below transition temp, liquid crystals align in their "nematic" phase and force stretching of the elastomer network

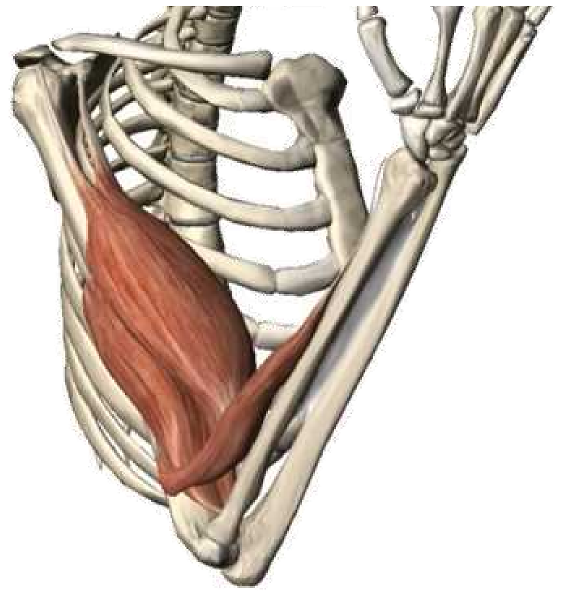
Molecule domains are aligned







Above transition temp, liquid crystals lose alignment, allowing elastomer to contract

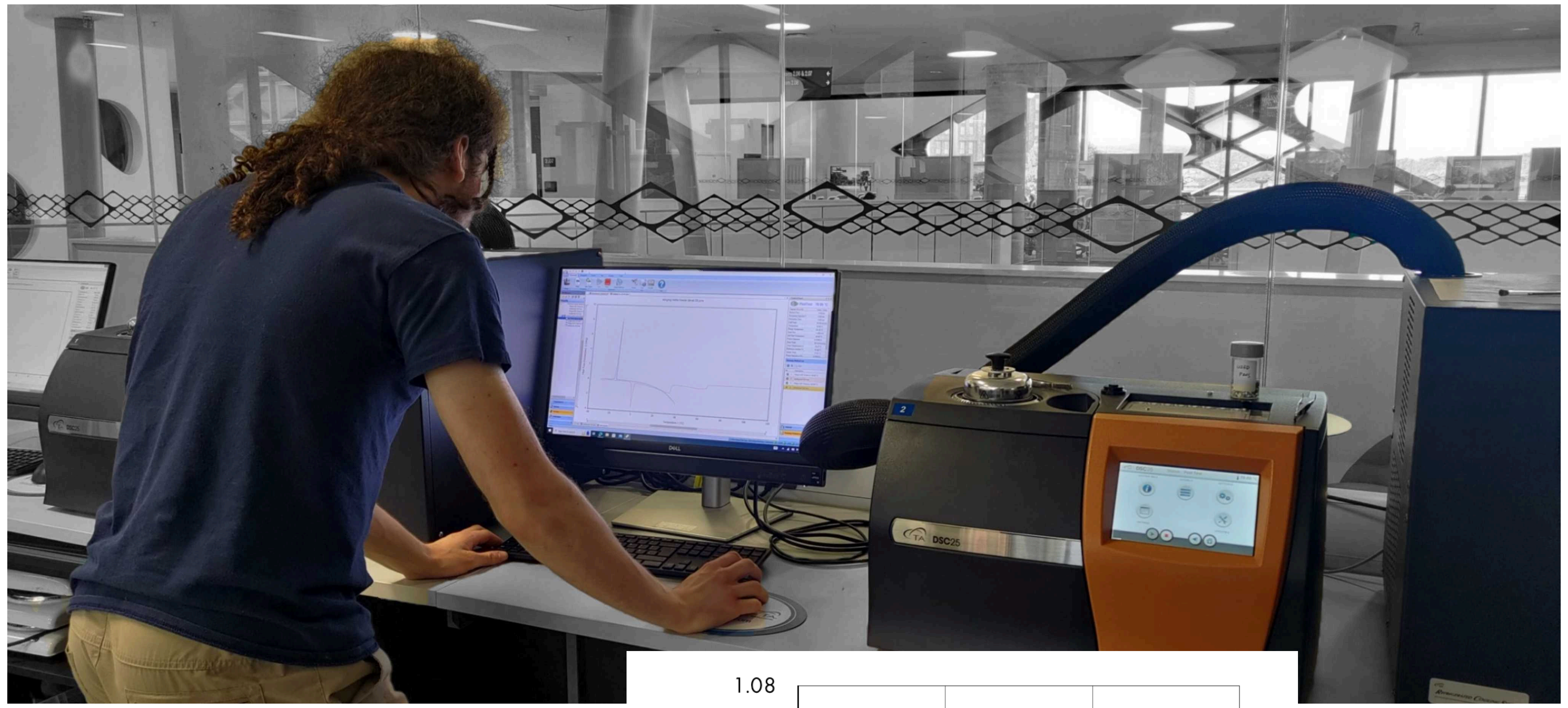


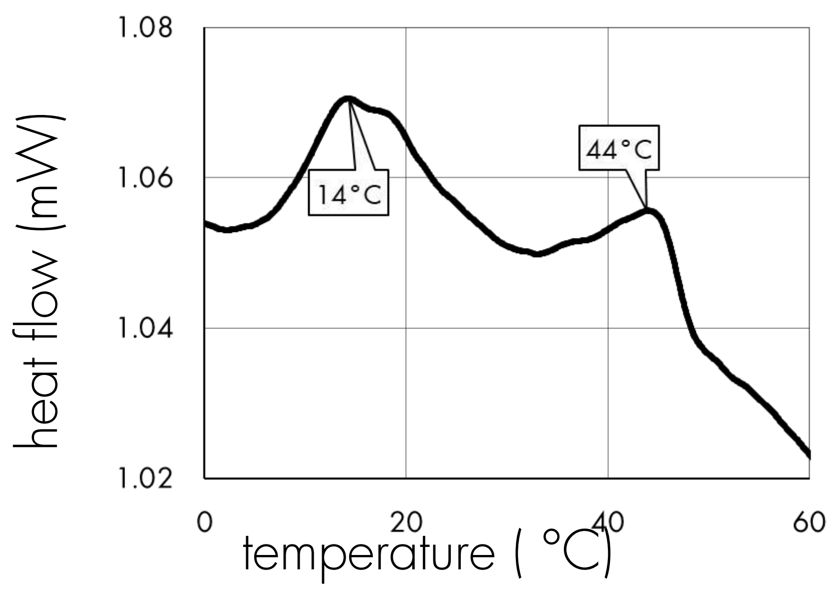
Characterising the material

was the key fist step in establishing it's usability. The aim was to observe the liquid crystals transition to alignment, establish the temperature at which the transition occurs, and confirm it's reversibility

X-ray diffractometer - huge electron accelerator (the Diamond Light Source) spits out ultra high powered X-rays. The X-rays are passed through the sample, and their interactions with it show the sample's structure

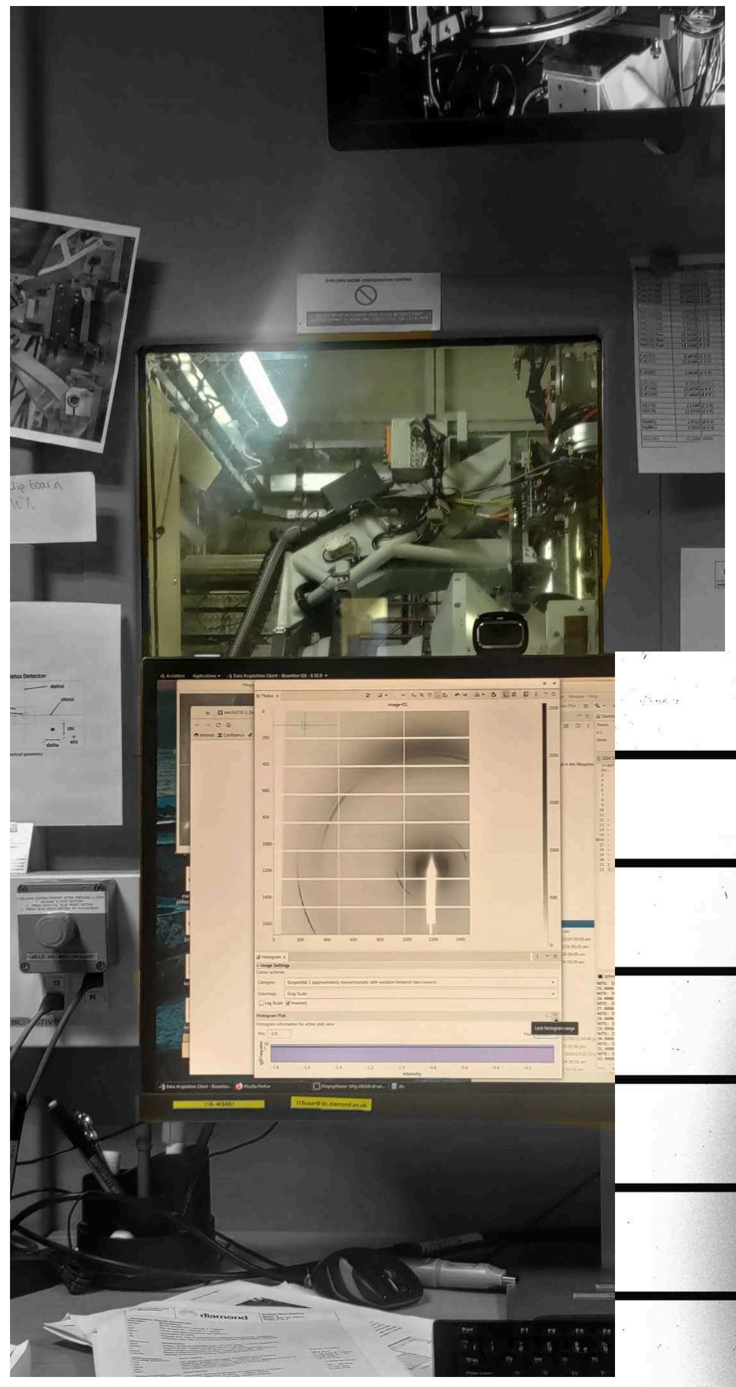
Differential scanning calorimeter - heats sample and observes changes in heat flow during transiitons

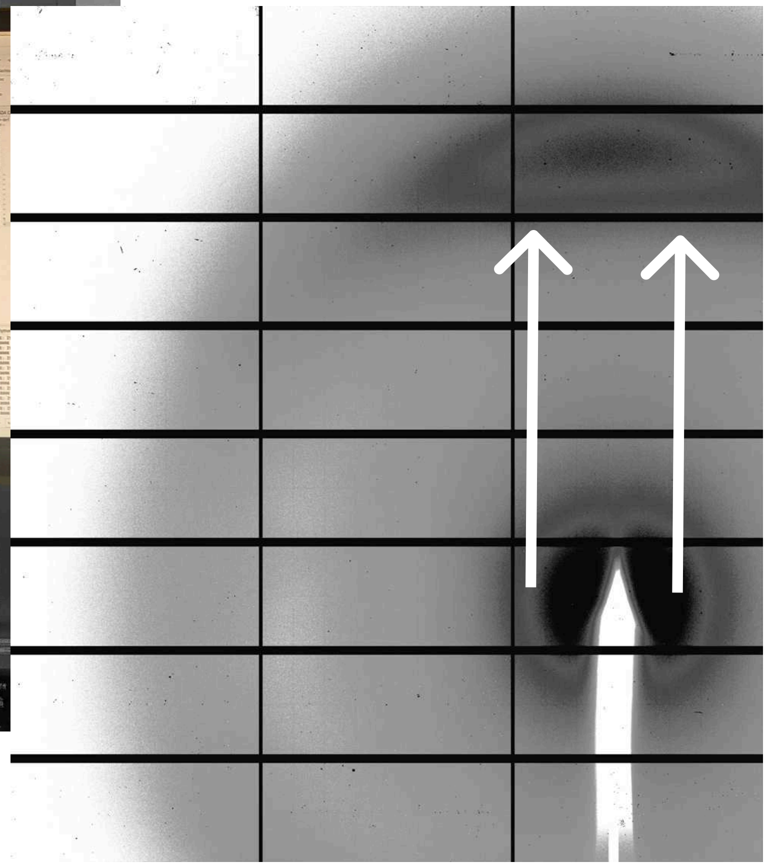




Graph showed transitions on both cooling and heating = reversible

Transitions located, and are lower than conventional LCE materials = better

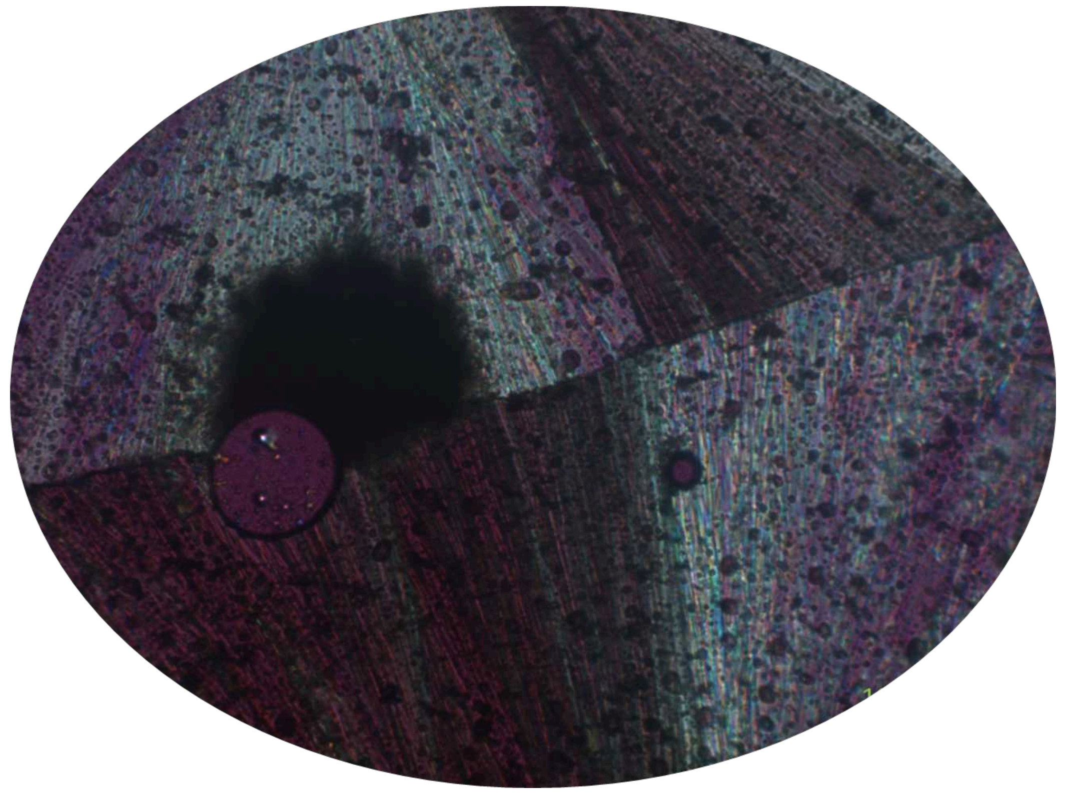




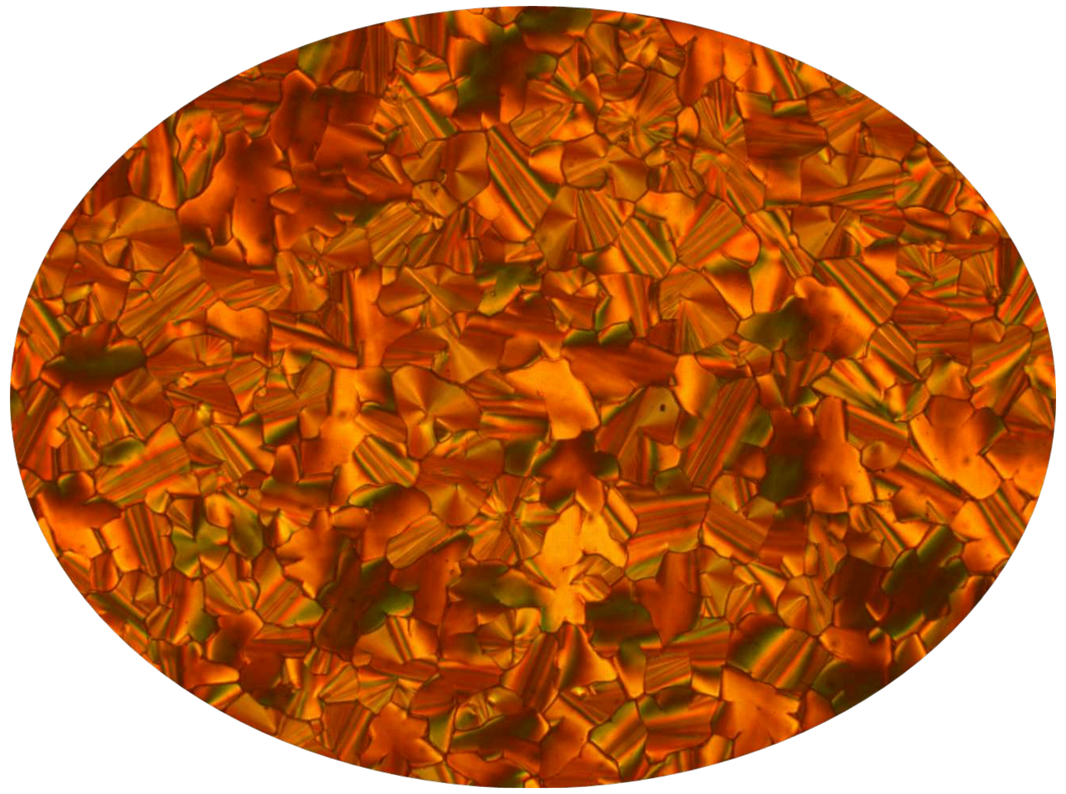
Directional response shows LCEs can align

A closer look

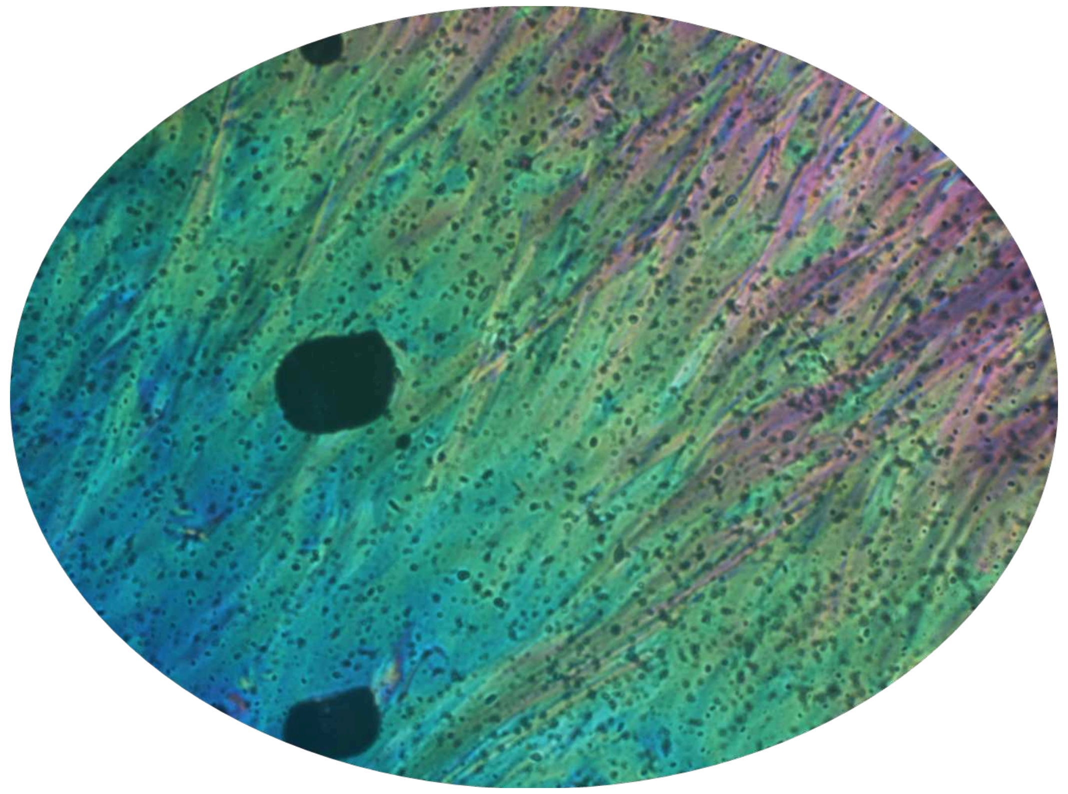
through a polarised optical microscope (POM) to explore the microstructure, and how it changes with stimulus



Some samples became crystalline on cooling, preventing actuation - not what we want



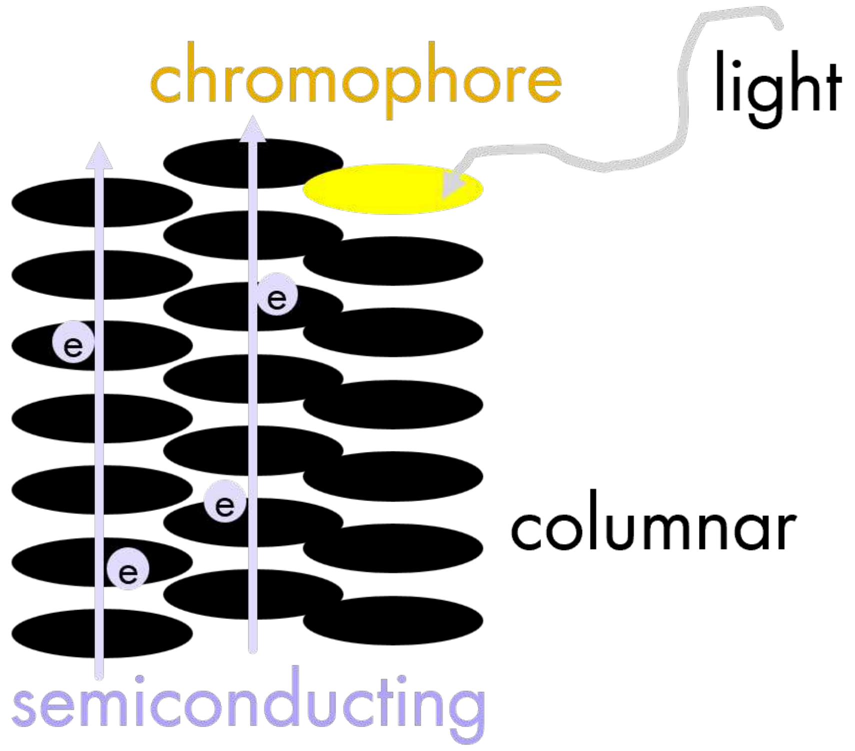
Some showed columnar phases, which brings unique properties

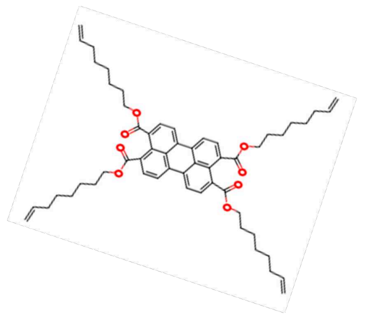


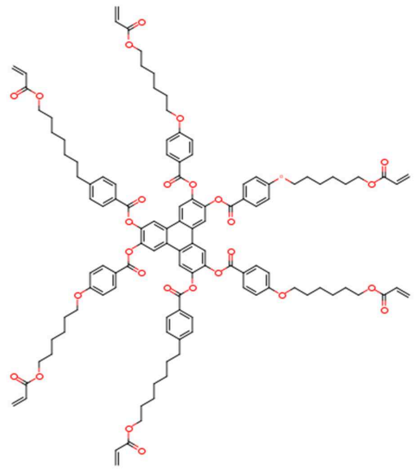
Some samples showed the "nematic" phase we were looking for

Responding to alternative stimuli than temperature

is a crucial property – electricity or light are far easier to control. Through POM I showed that our materials demonstrate this

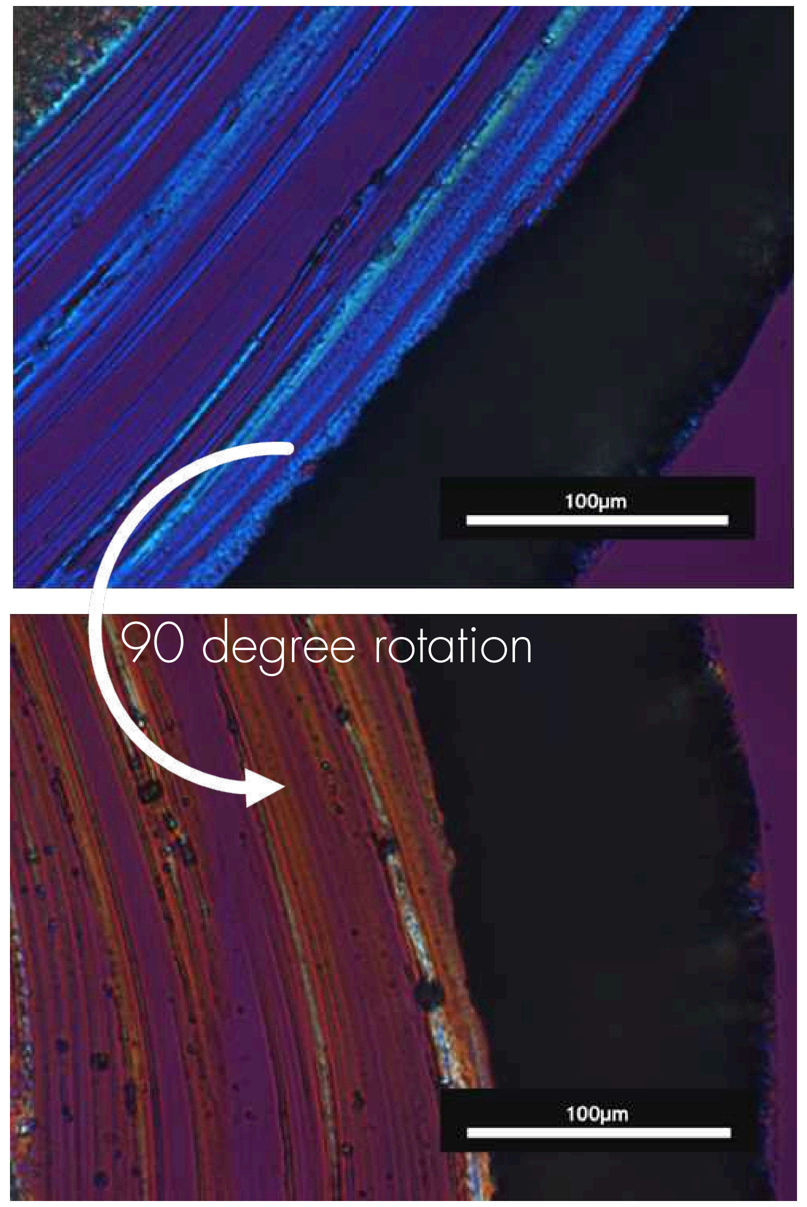






Future directions

To create actuation, the last crucial step was to simultaneously align and crosslink the liquid crystal molecules together to form the elastomer network. While alignment was achieved, crosslinking was unsuccessful. Future research involves using UV crosslinkers to create the elastomer network using UV light. This also would allow for greater control of the crosslinking, and by extension, of the actuation response. This could open possibilities for novel micro scale sensors that respond to biological signals, or light powered micro-actuators.

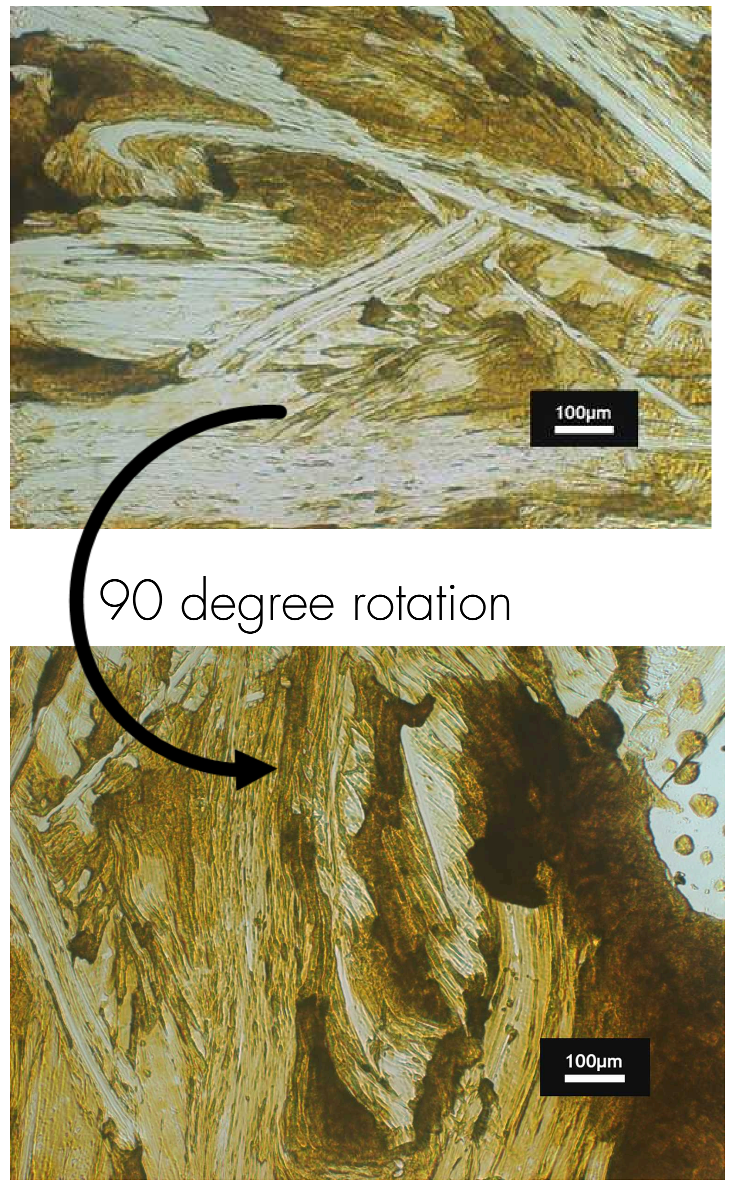


Colour change of some samples through rotation underneath polarised filters prove alignment of domains – step one achieved

My attempt at creating fibres, hypothesising crosslinking of reactive end groups with heating.

This did occur, but the reaction couldn't complete.

As such, the fibre disintegrated.



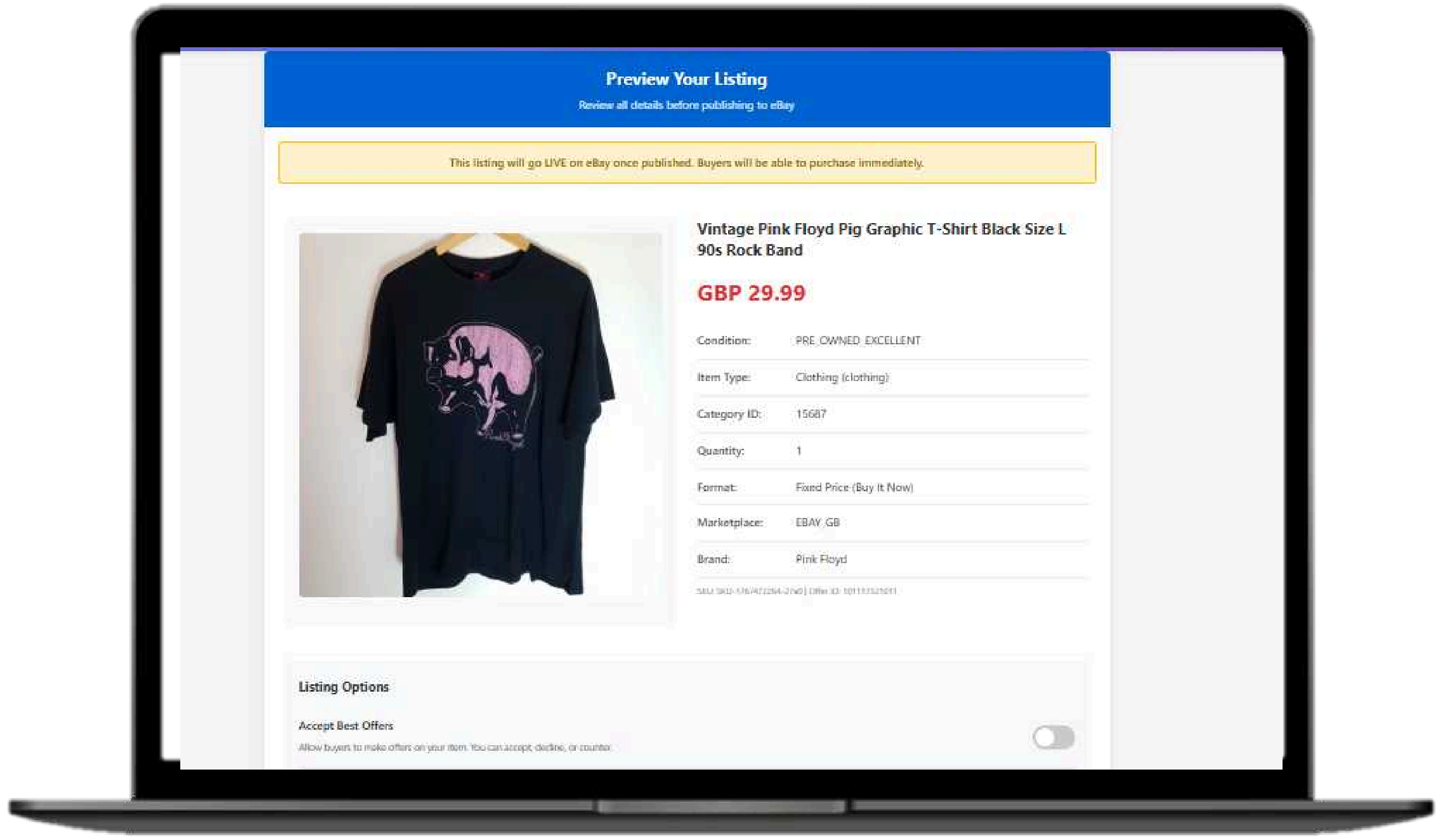
Colour change of one special sample through rotation WITHOUT polarisers indicates linear dichroism – unique light stimuli responsive properties

AI automation

Individual side project: Making e-commerce admin painless (or at least less painful)

Key skills: python, html, css, UX, flask app development, utilising APIs and prompt engineering

User takes a photo

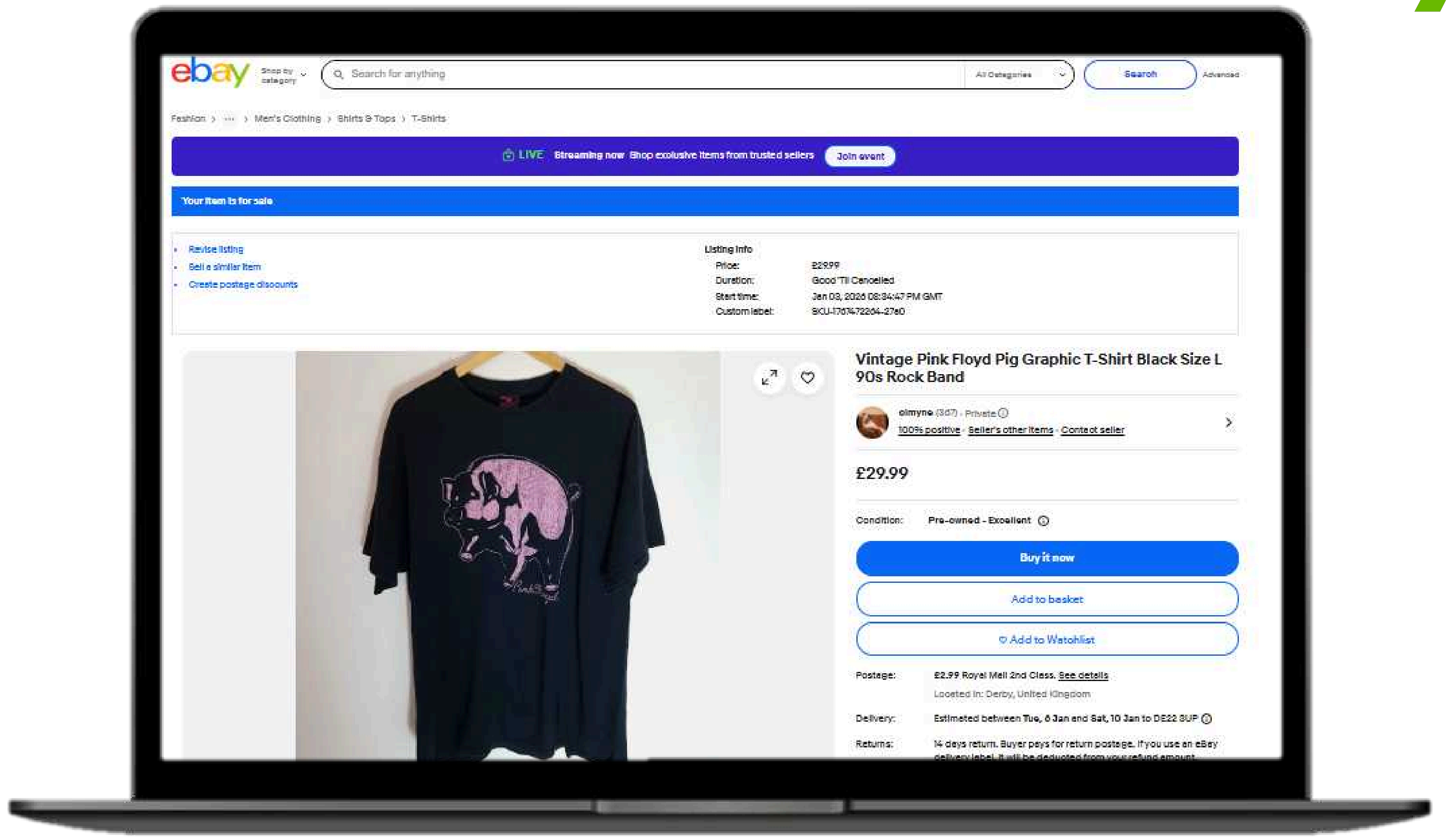


Draft listing created, user can edit

Listing stock is arduous

I wanted to make it less so. The program allows small business owners to simply upload a photo of their item, and uses an LLM API to analsye and write a full listing, ready to upload. Time is saved for more productive/ enjoyable activities

I use this system to manage my vintage clothing resale e-shop



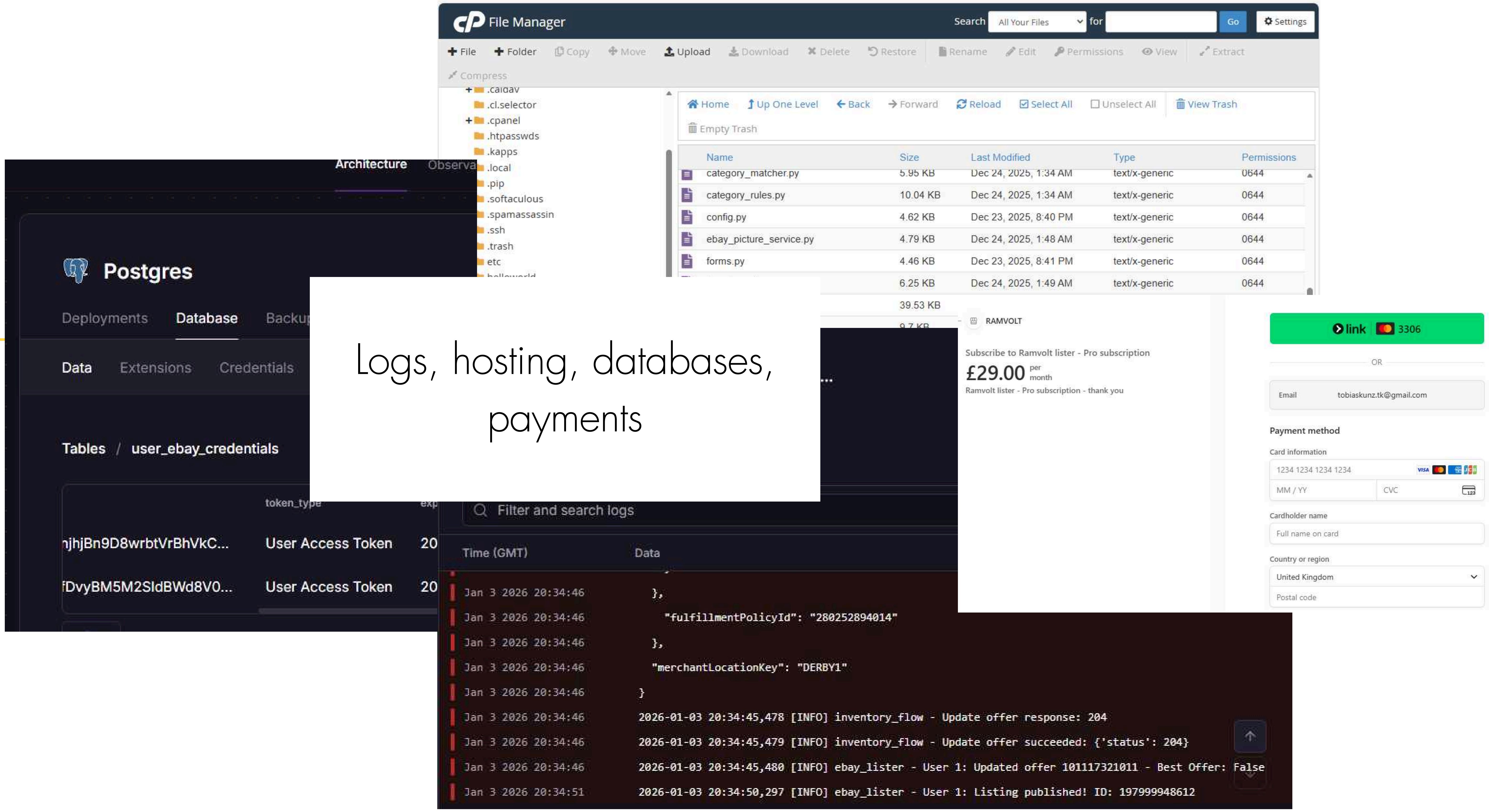
Listing ready to roll!

I'm builiding it out

Into a full SaaS app. If I needed this, other people are likely to need it too. Currently there's nothing on the market this fast.

I've learnt how to get through the obstacles to actually shipping a product

Next step - marketing through ebay influencers, creating a product so good they will gladly recommend it to their audience



Logs, hosting, databases, payments