Bioprinting @ Berkeley - Aesthetic Prosthetic

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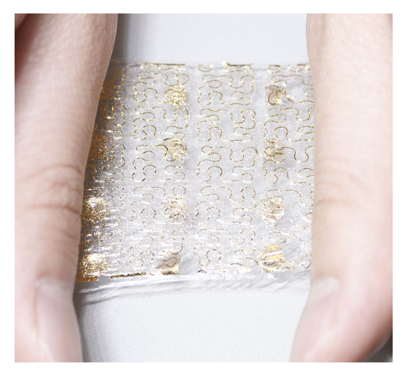
The Evolution of Prosthetics

Prosthetics and artificial limbs. Thanks to the advancement of technology and the rise of generation of information, prosthetics are more familiarized and have become well known for its ability to give the user motor functionality. But prosthetics have come a long way; the first confirmed prosthetic device, was from 950 to 710 BC. Pathologists discovered a mummy buried in the Egyptian necropolis near ancient Thebes that possessed an artificial big toe that was made with wood and leather. And since then, the ancient Romans around 300 BC constructed the "Capula leg" from wood, bronze and iron; around 1863-1945 during the times of the American Civil War, hand prosthetics transformed from wooden pieces to cosmetic rubber; in the 1970s-1990s, we finally see significant advancements in prosthetics with the use of plastics, polycarbonates, resins, and laminates that allowed for a lighter and manageable design. And in the last 2 decades, the idea of high-performance prosthetics were brought to life using carbon fiber and advanced technology.

But why did we bother to tell you this? Because we would like you to focus on the materials used throughout the ages. From wood and leather, then adding bronze and iron, then replacing those materials with plastics and other polymers, to adding carbon fiber and an abundance of electronics and technology, we have progressed towards better prosthetics largely by changing the materials used. And now, we believe that **we are approaching a new generation of prosthetics where we are adding a new component: biomaterials.**

Currently we have realistic prosthetics and also high functionality prosthetics but one comes with the cost of another. The best example of a prosthetic that has almost best of both visual and functionality is one from Truelimb. However, even Truelimb does not use biomaterials or materials close to a human skin, nor does it have sensors for instantaneous feedback to the users. This is where our team would like to come in.



Goals

Big Goal:

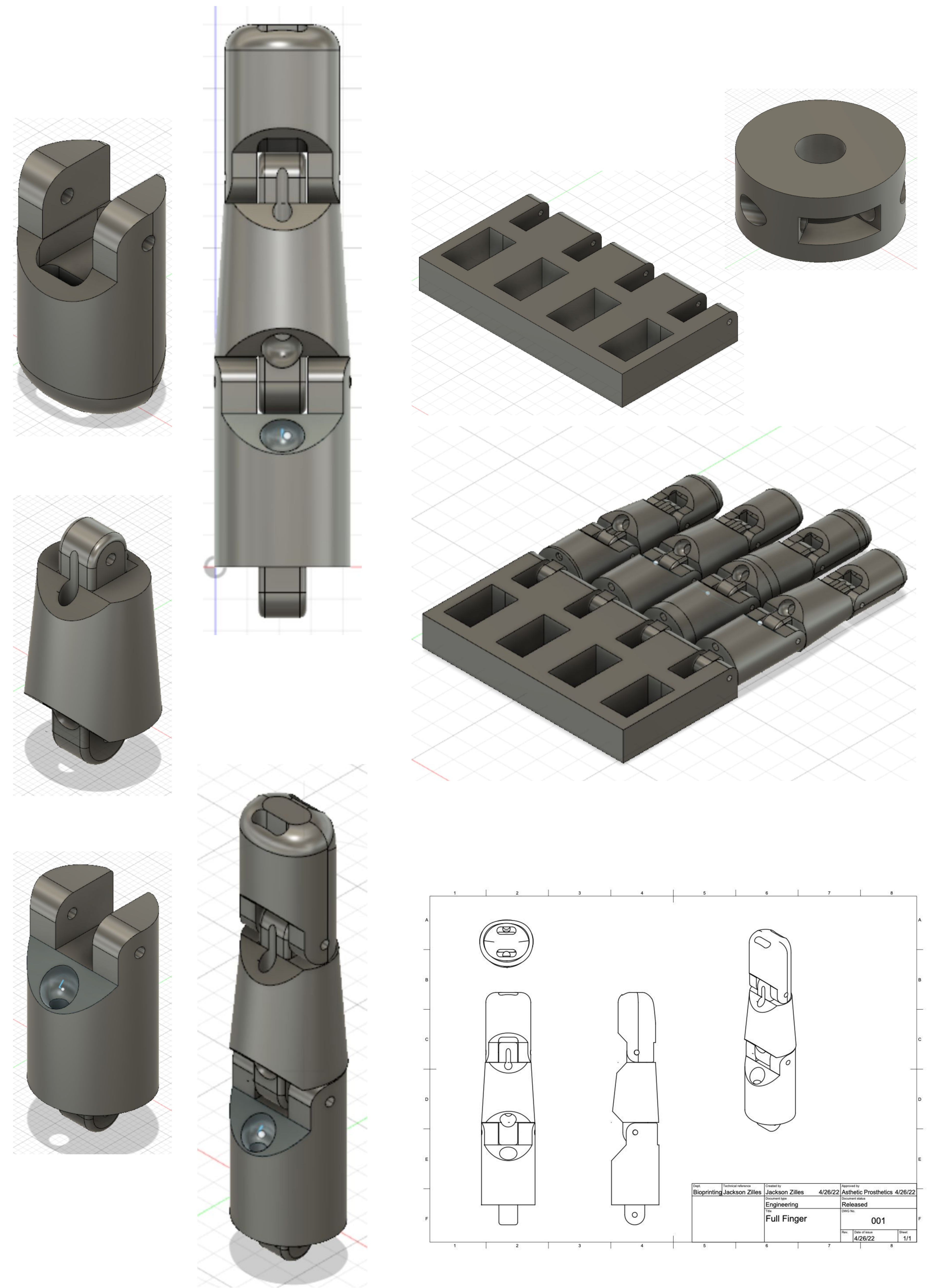
Create a bionic arm that utilizes a skin like material with sensors that envelops the prosthetic arm to provide functionality, realistic feel and aesthetic.

Preliminary Goals:

Design and create a functional prosthetic arm/hand that serves as a base to wrap the skin like material around.

Acknowledgements:

Designs



Design Considerations

Advancements/Ideas
- Finger prototypes
  - Assembled pieces
- Motor application
- Rope vs. fishing line
- Integration of haptics

Faults/improvements
- Joint rotation
- Connection with the palm
- String attachments

Ongoing and Future Works

Progress so far:
- Fully 3D printed finger
- Motorized and flexes on command

Future works:
- Palm and thumb mechanics
- Solidify on a model to keep working with
- Create bioprinted skin
- Layering bioprinted skin with sensors
- Designing compatibility with bioprinted skin with 3D printed prosthetic
- Develop electronic component to move hand
- Research on what material is most compatible with our skin like material

References

- https://www.aalos.com/brief-history-development-evolution-prosthetic-limbs/
- https://www.bbc.com/future/article/20151030-the-geniuses-who-invented-prosthetic-limbs
- https://www.unlimitedtomorrow.com/get-a-truelimb-today/?gclid=CjwKCAjwsJ6TBhAIEiwAfl4TWCTsjzgj3_Ud4vb_M23GU7uPZ6_HgFo0EwT--9v0InT6pEhflo4VPhoCCjgQAvD_BwE

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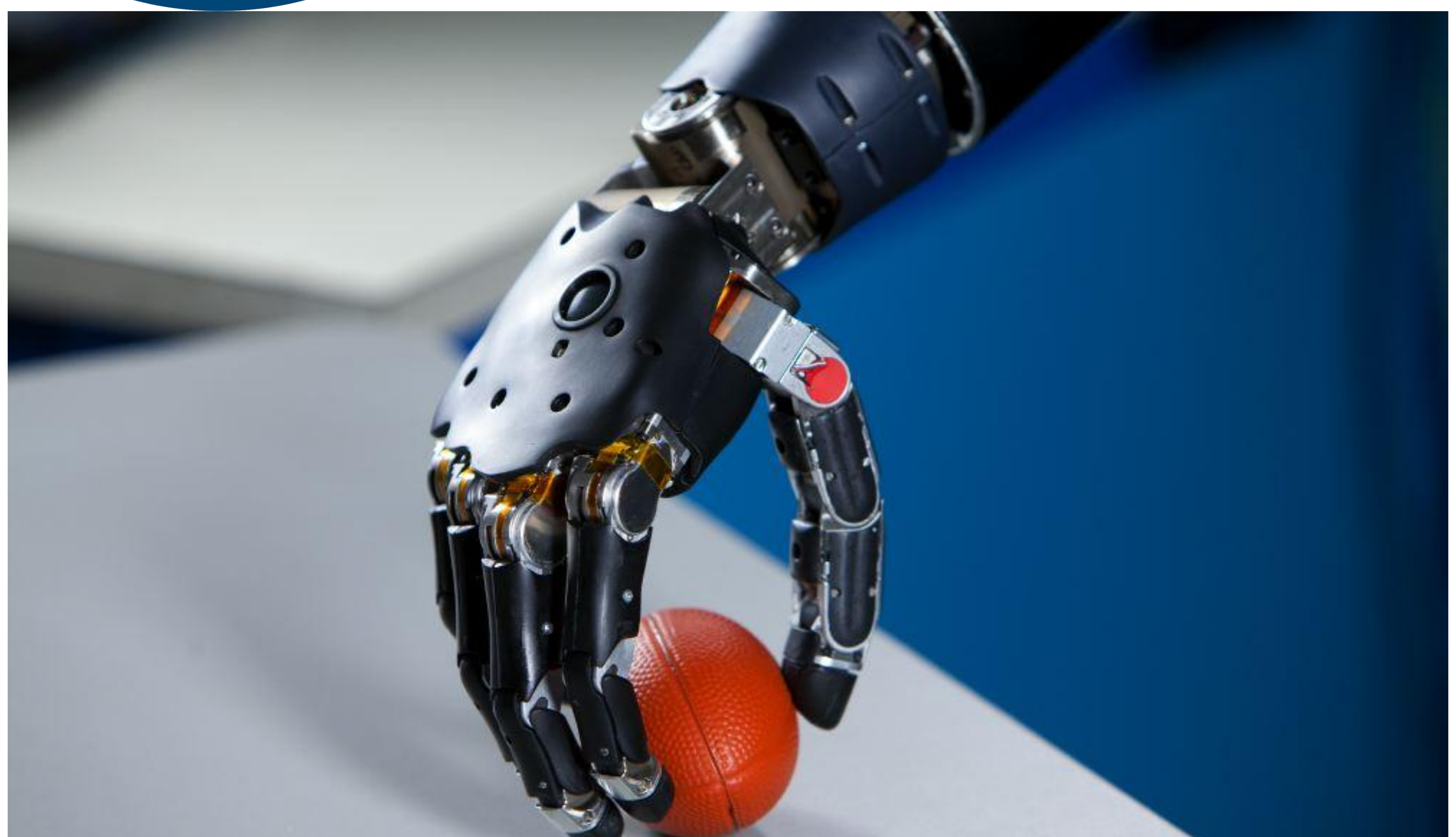
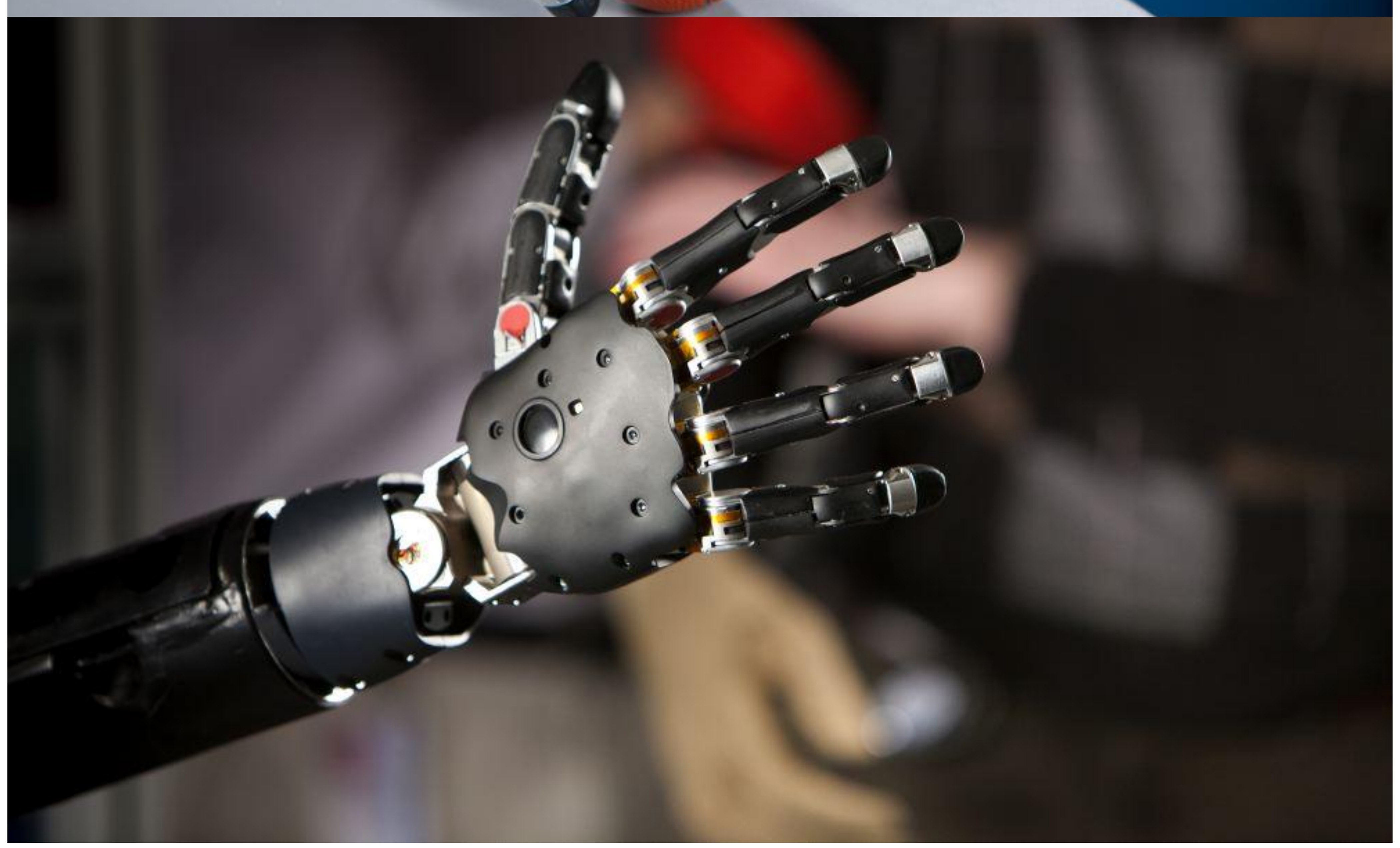
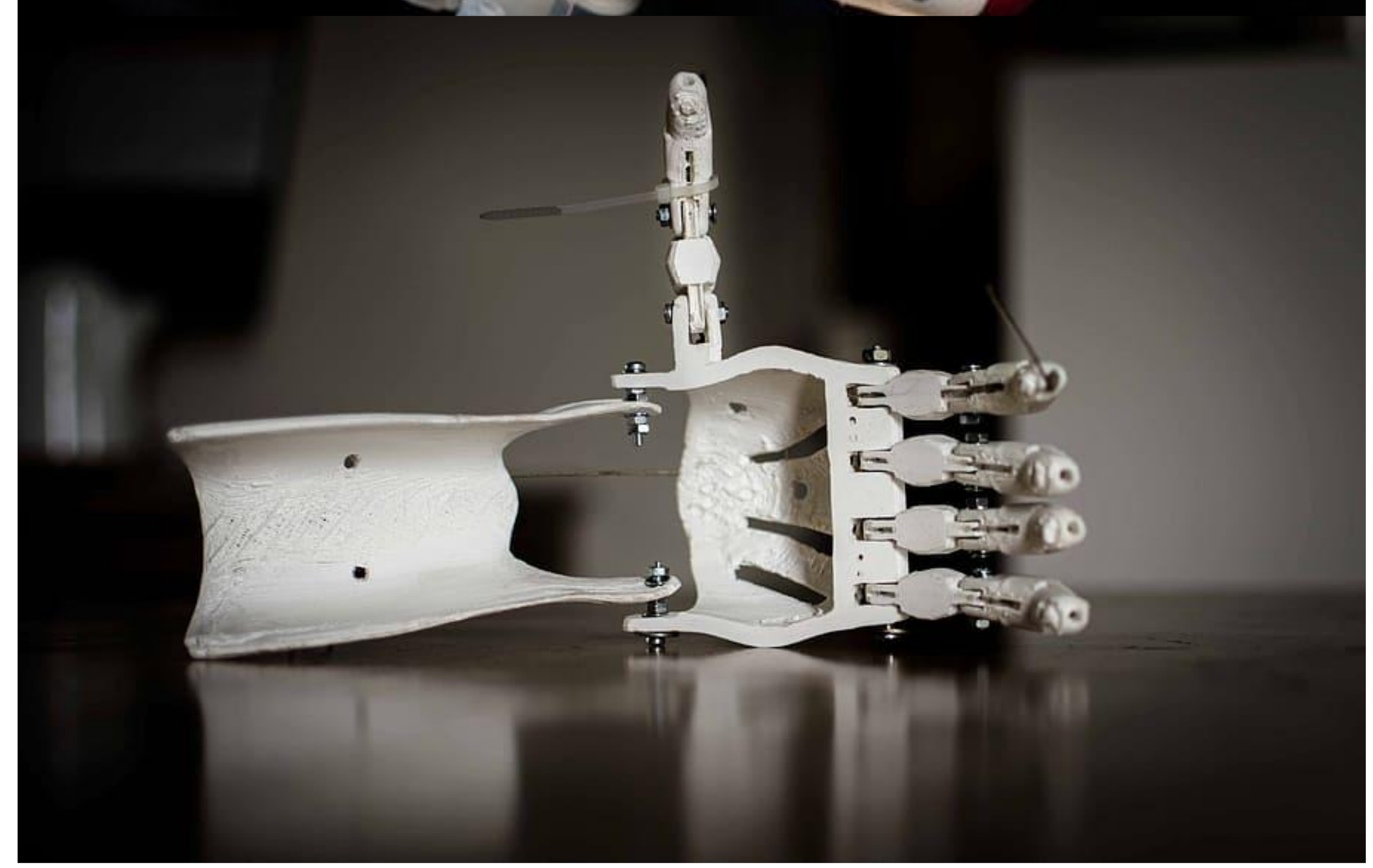






Prosthetics

Put shortly, have come a long way.

We have progressed towards better prosthetics largely by changing the materials used. And now, we believe that **we are approaching a new generation of prosthetics where we are adding a new component: biomaterials.**

Leather, Wood

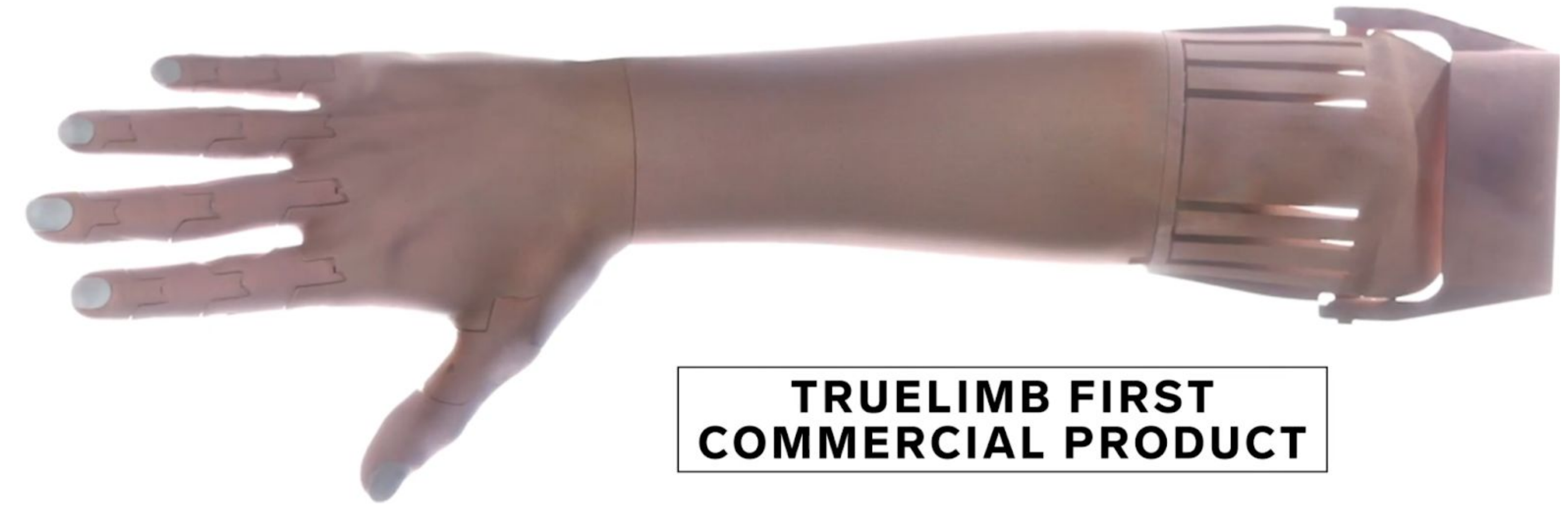
Wood, Bronze, Iron

Rubber

Plastics, polycarbonates, resins, laminates, carbon fiber

Biomaterial

The Problem



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However, even Truelimb does not use biomaterials or materials close to a human skin, nor does it have sensors for instantaneous feedback to the users. This is where our team would like to come in.

So how are Bionic arms different than prosthetics?

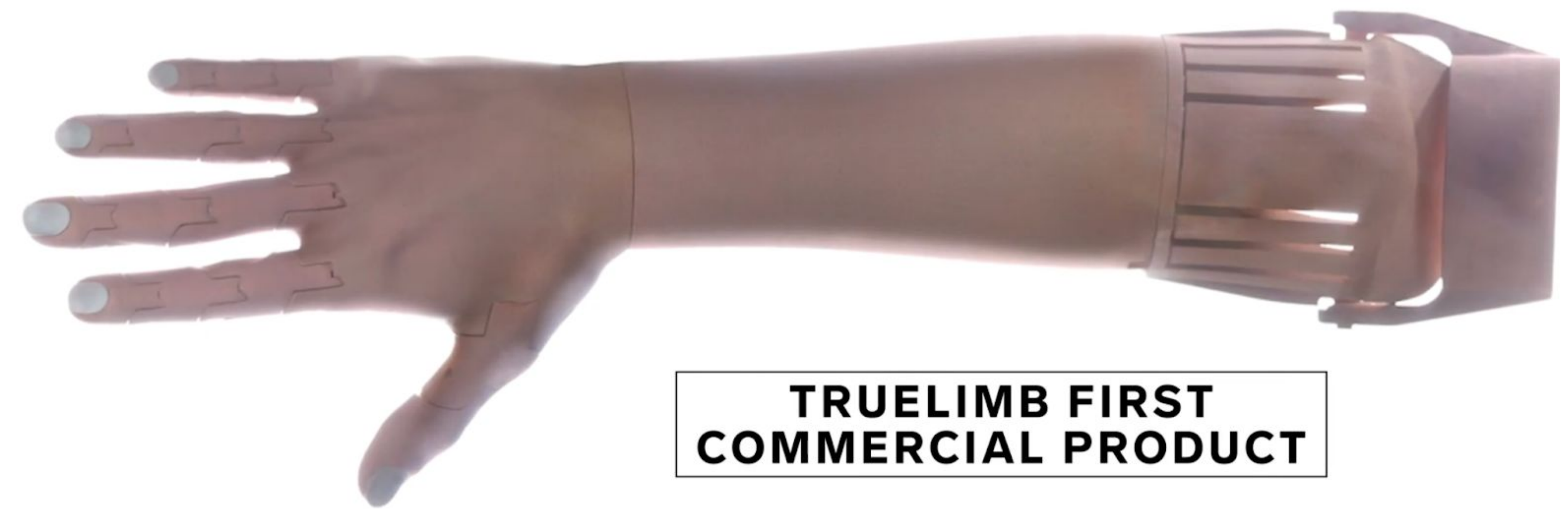
Bionic arms contain sensors that press against the skin of the wearer's residual limb. The sensors are trained to translate electrical signals from the person's nerves into commands for the bionic arm.

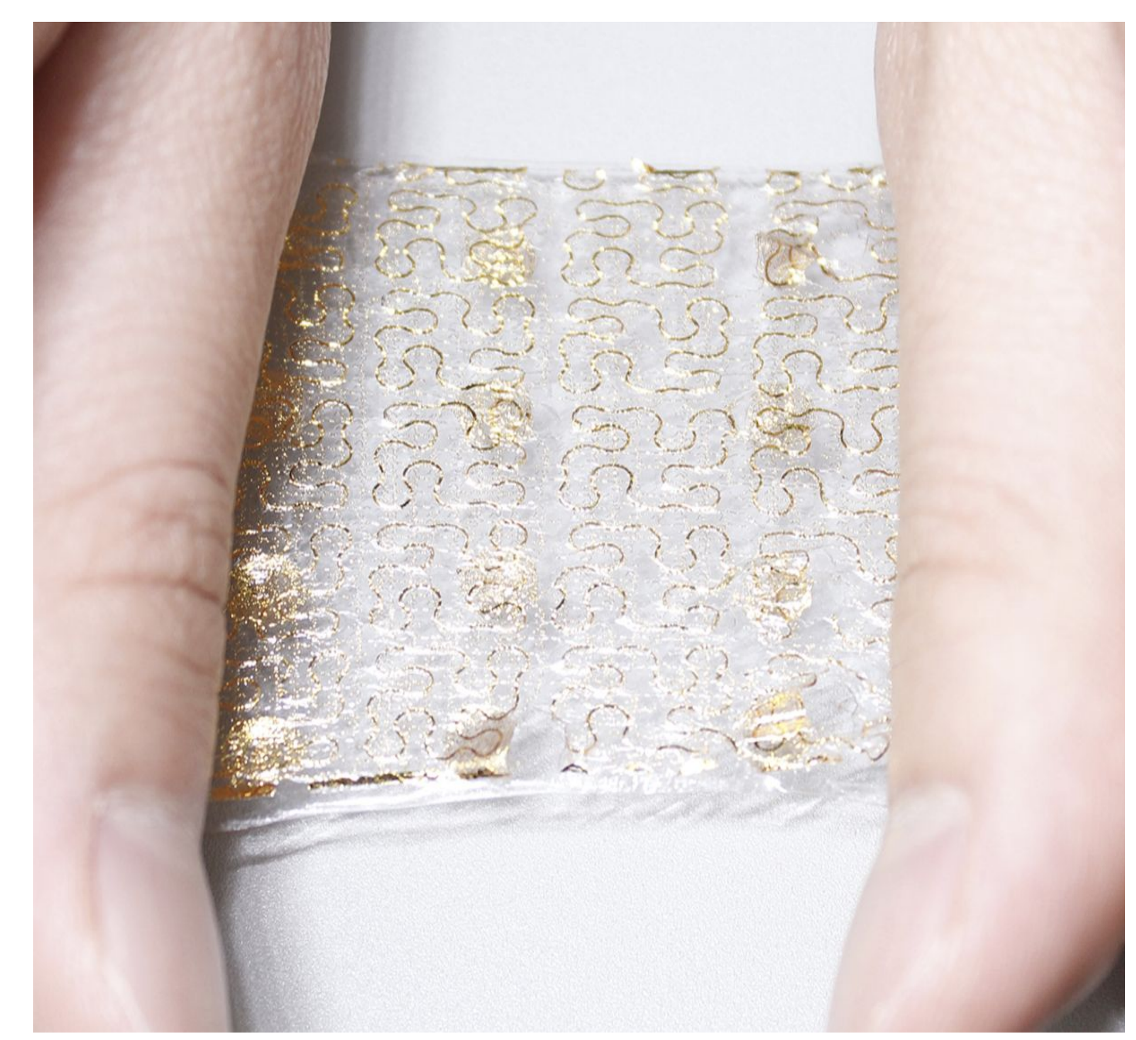
The problem is this system usually only allows for one-way communication. We know that bionic arms possess some limitations such as implant stability, bone fracture, breakage of the implant parts and infection.

The goal of the project

Improvement of modern day Prosthetics

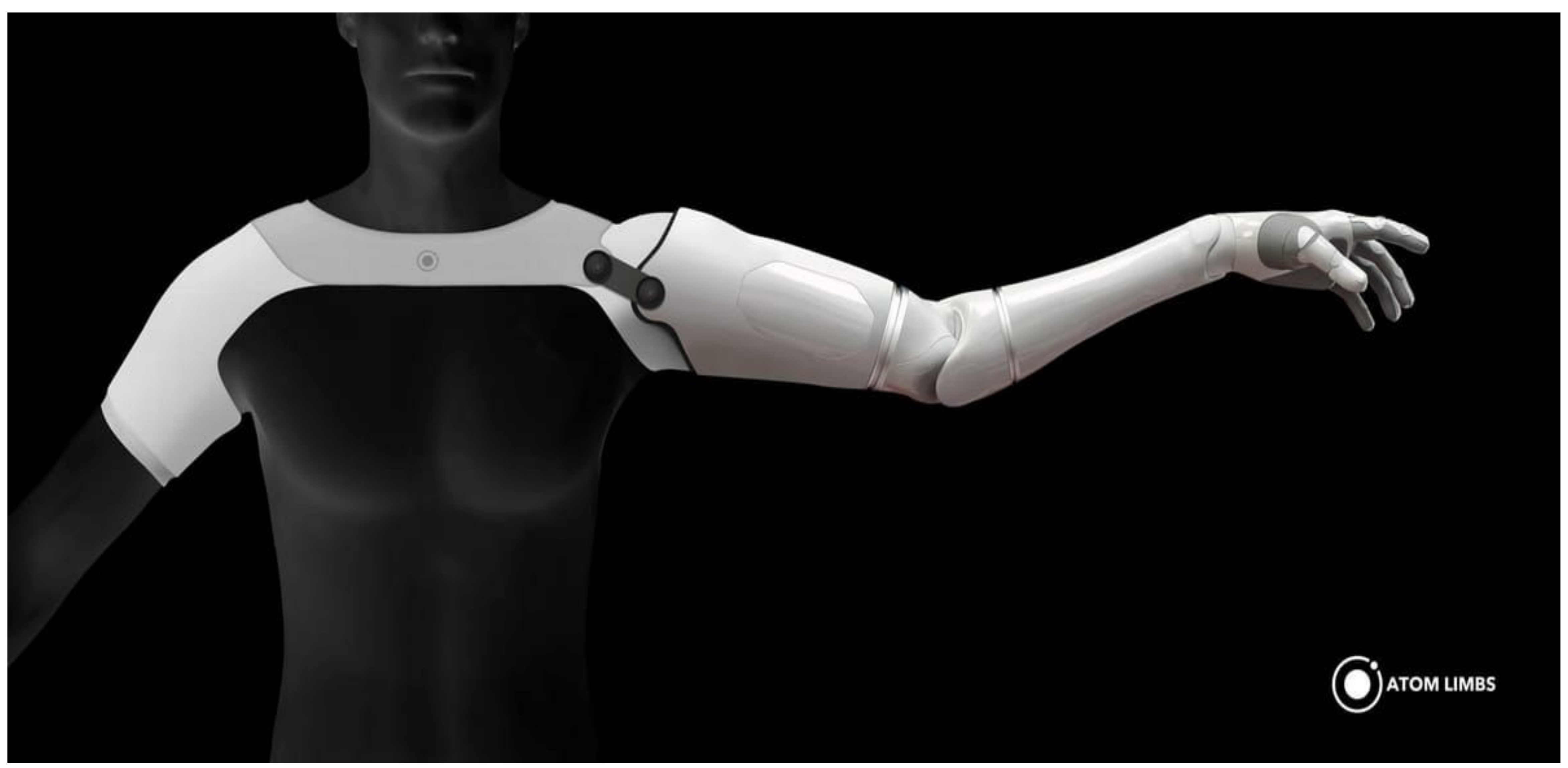
1) Aesthetic Bioprinted design; Looks and acts like a real hand
2) Reliability; Grip strength and indication of usage.
3) Nerve detection and censor grafts; Body to Prosthetic translation of movement
4) Moreover, have us develop designing skills as an engineer





Existing solutions

Atom Touch: $50k-100k bionic arm with hundreds of sensors capable of generating four types of sensory data: contact, force, position, and velocity.



Body-Powered Prosthetics: ~$5k arm that allows the person to use their shoulder and back to open and close the hook. Moving one's shoulder and upper limb to control precise terminal device limits can result in overuse and repetitive stress injuries.

Updates on Teams this semester

4 Sub teams

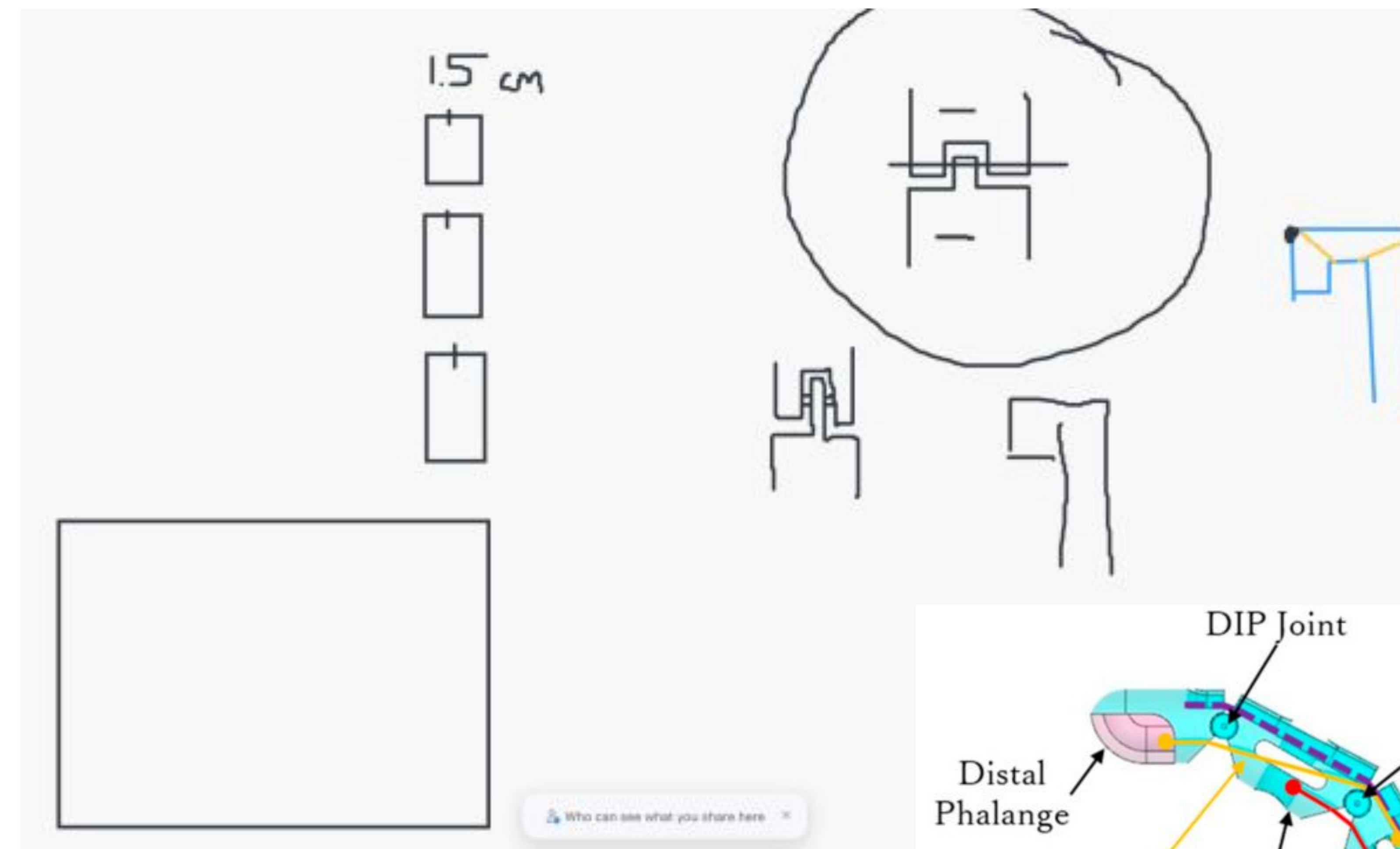
Fusion 360 Tutorials

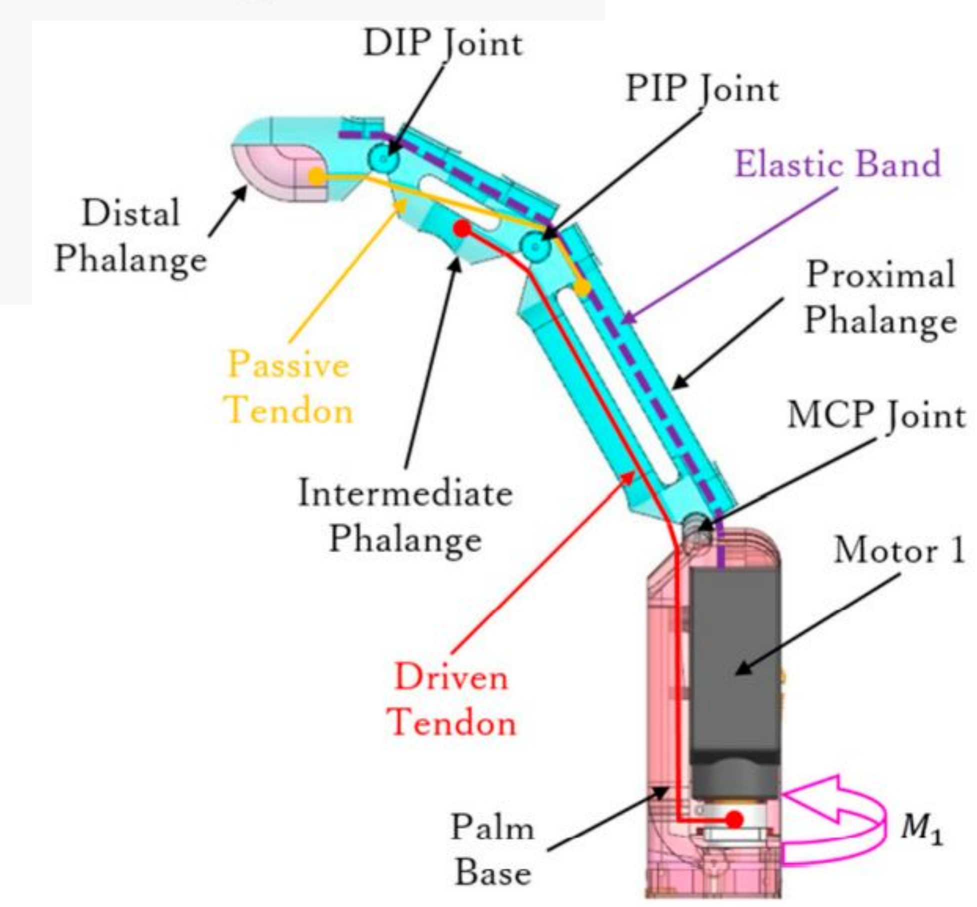
Assignments:

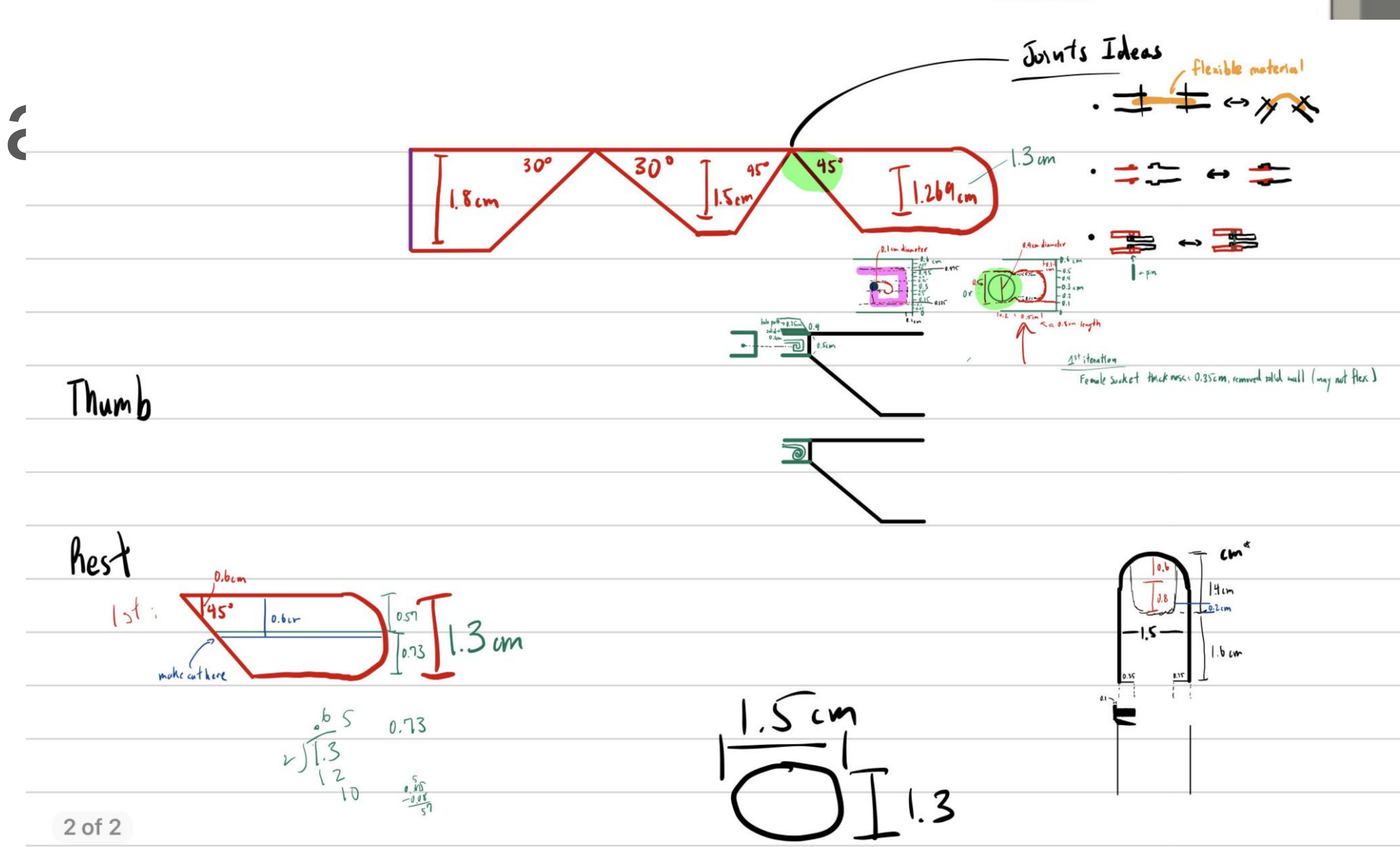
- Free themed CAD assignment
- Brainstorm Design

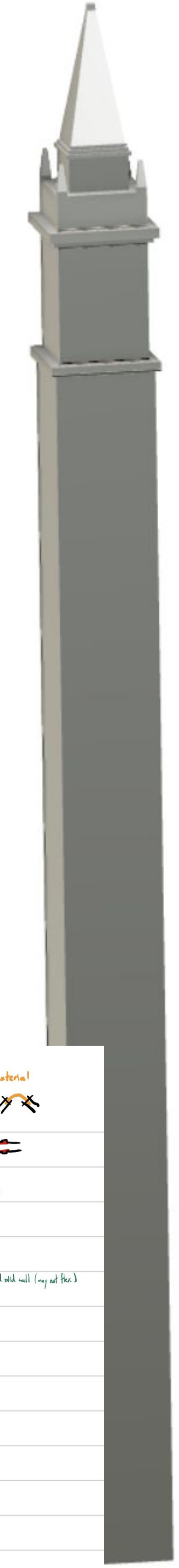
Super Chill semester:

- Next semester will be focused on having
  polish final presentation/deliverable



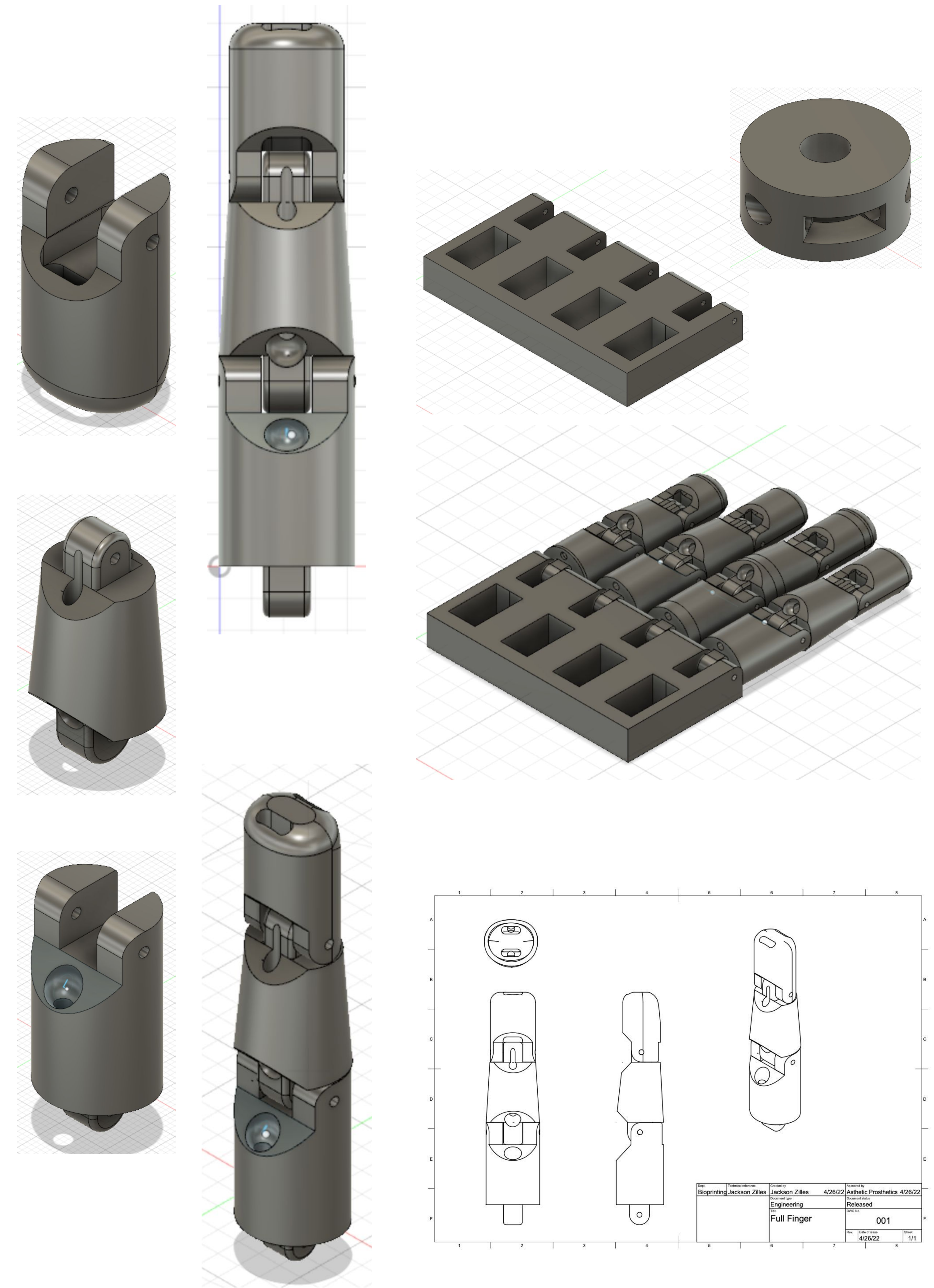




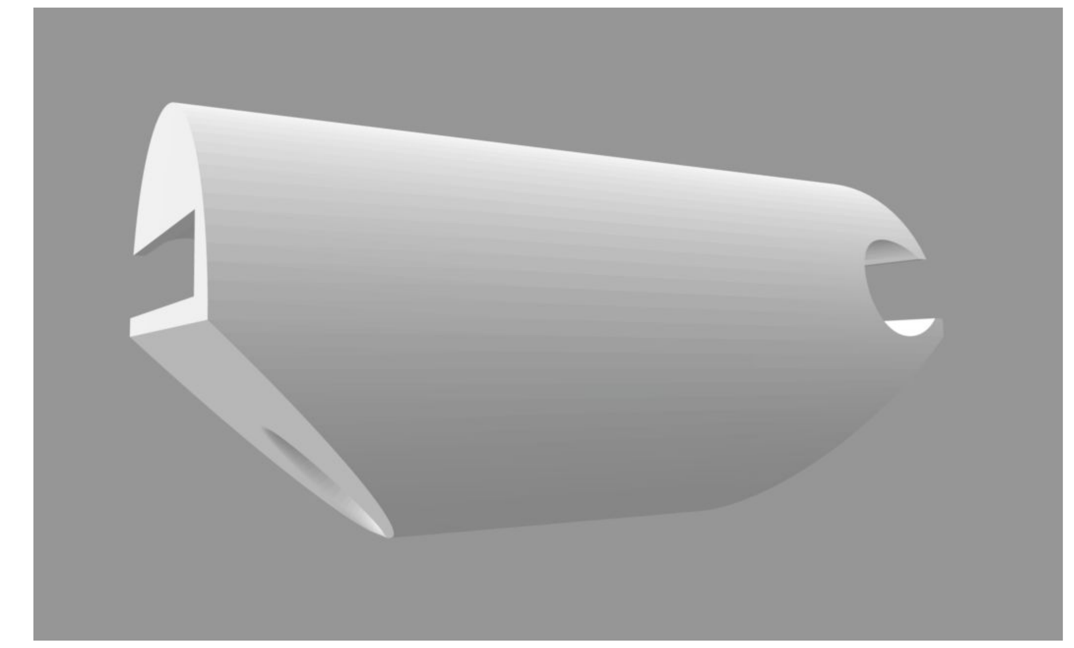


Bionic Arm Progress

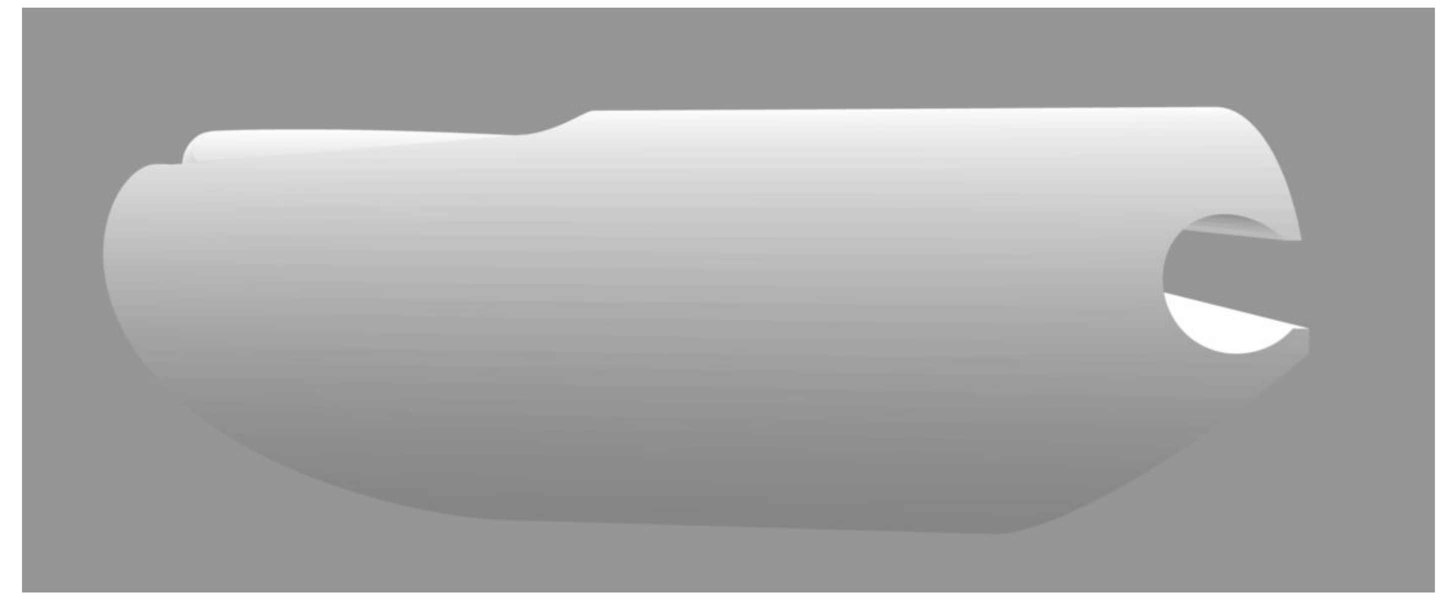
- Finger Joints
  - 3 individual pieces, connected via plastic axles
  - Cutouts for appropriate bend angles
  - Holes for pulley wire
- Palm
  - Minimum viable product for testing
  - Mount holes for servo motors
  - Rounded connection points for fingers
- Servo Horns
  - Custom servo horns to increase radius of servo, increasing pull length without compromising palm height

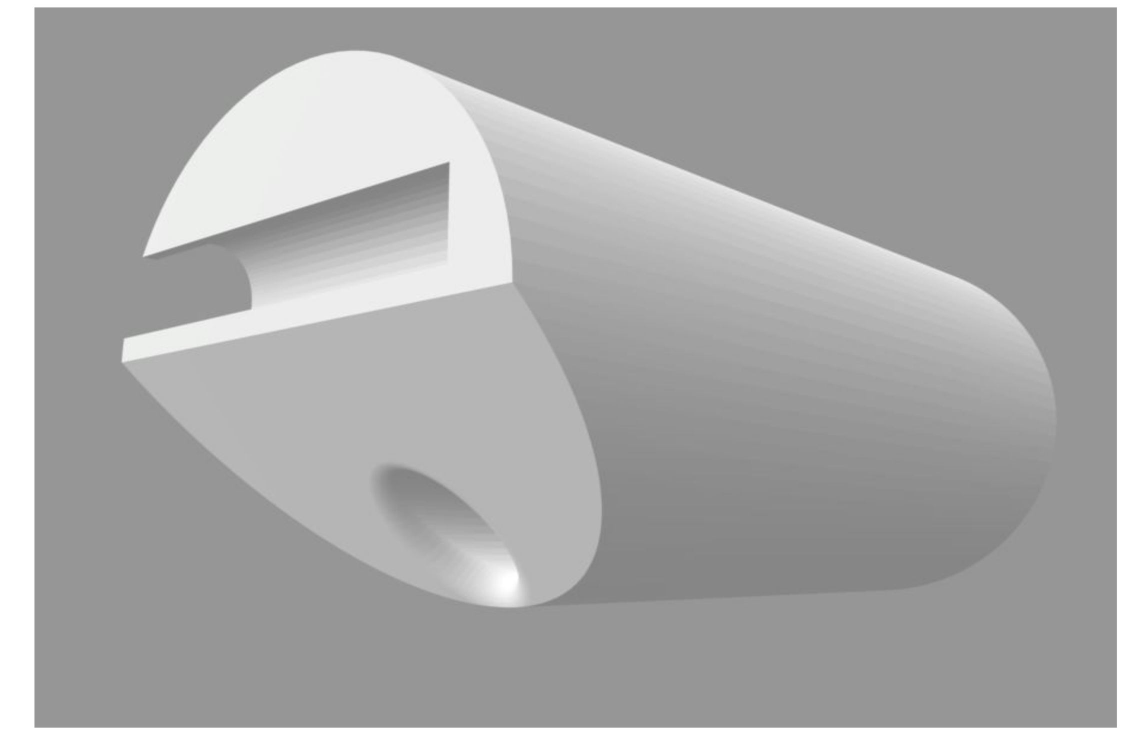


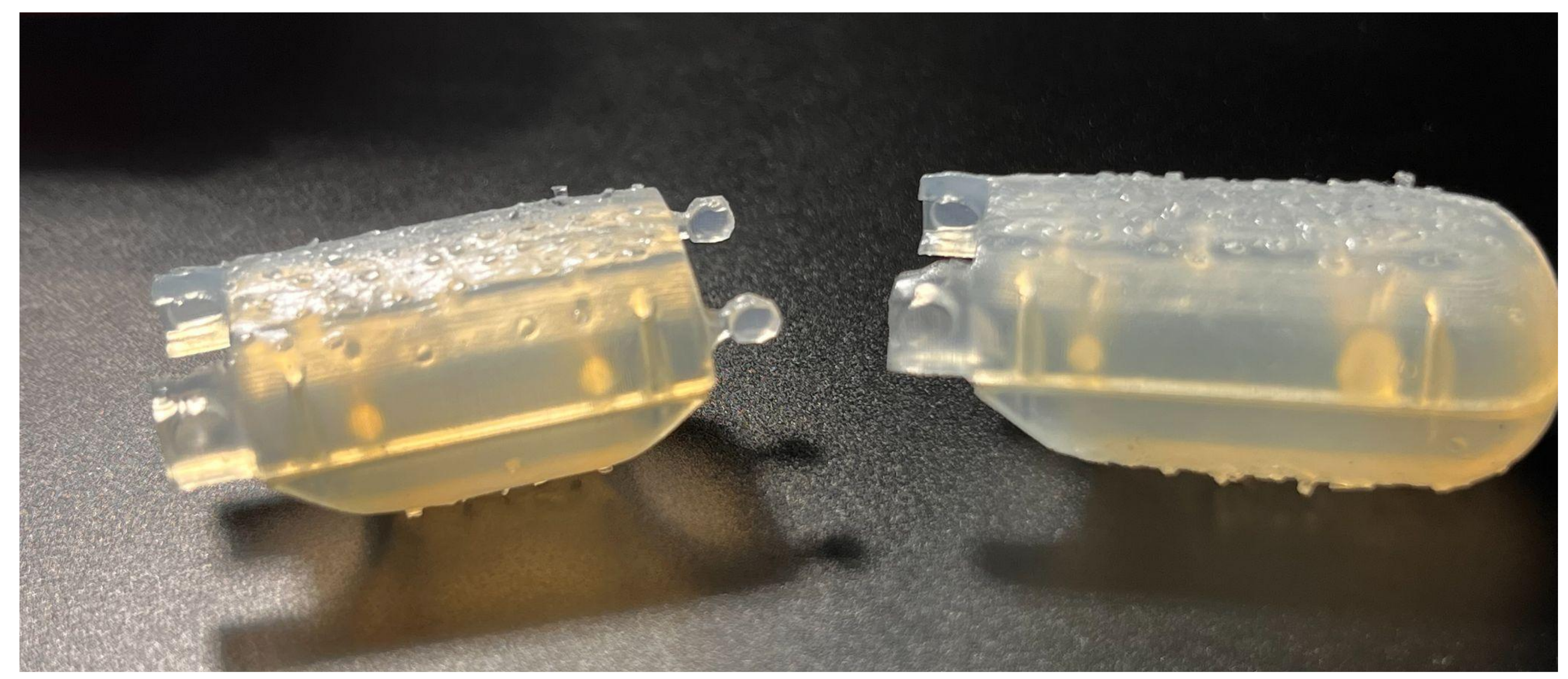
What we have been working on

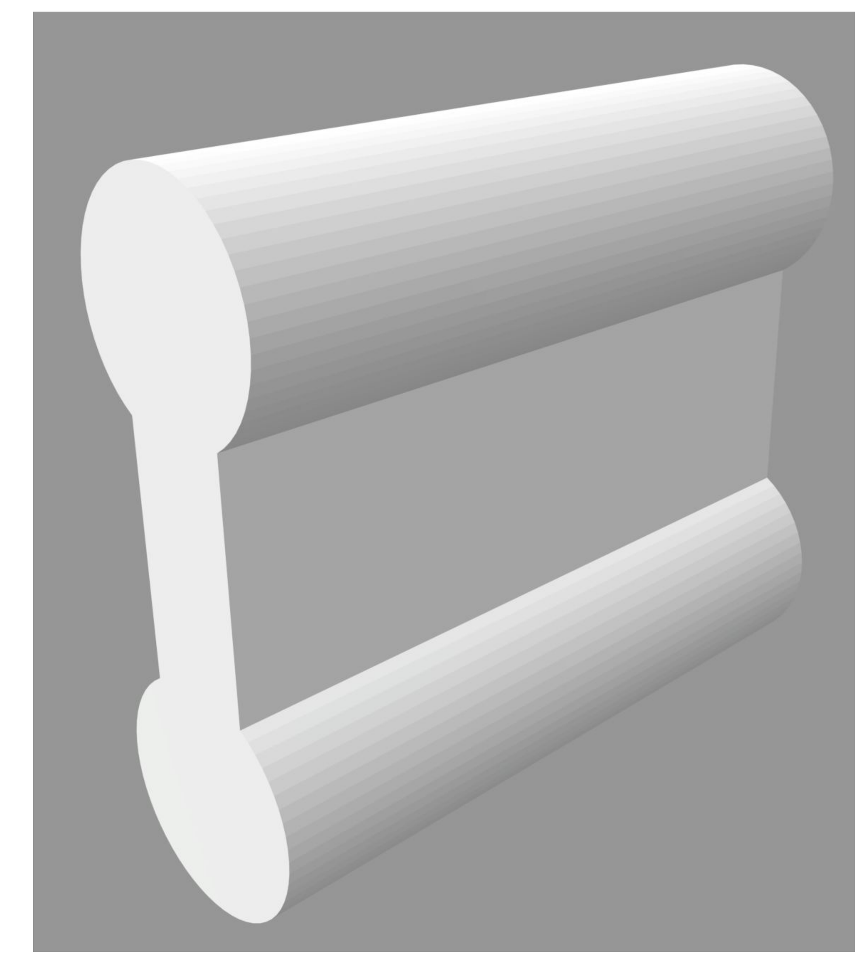


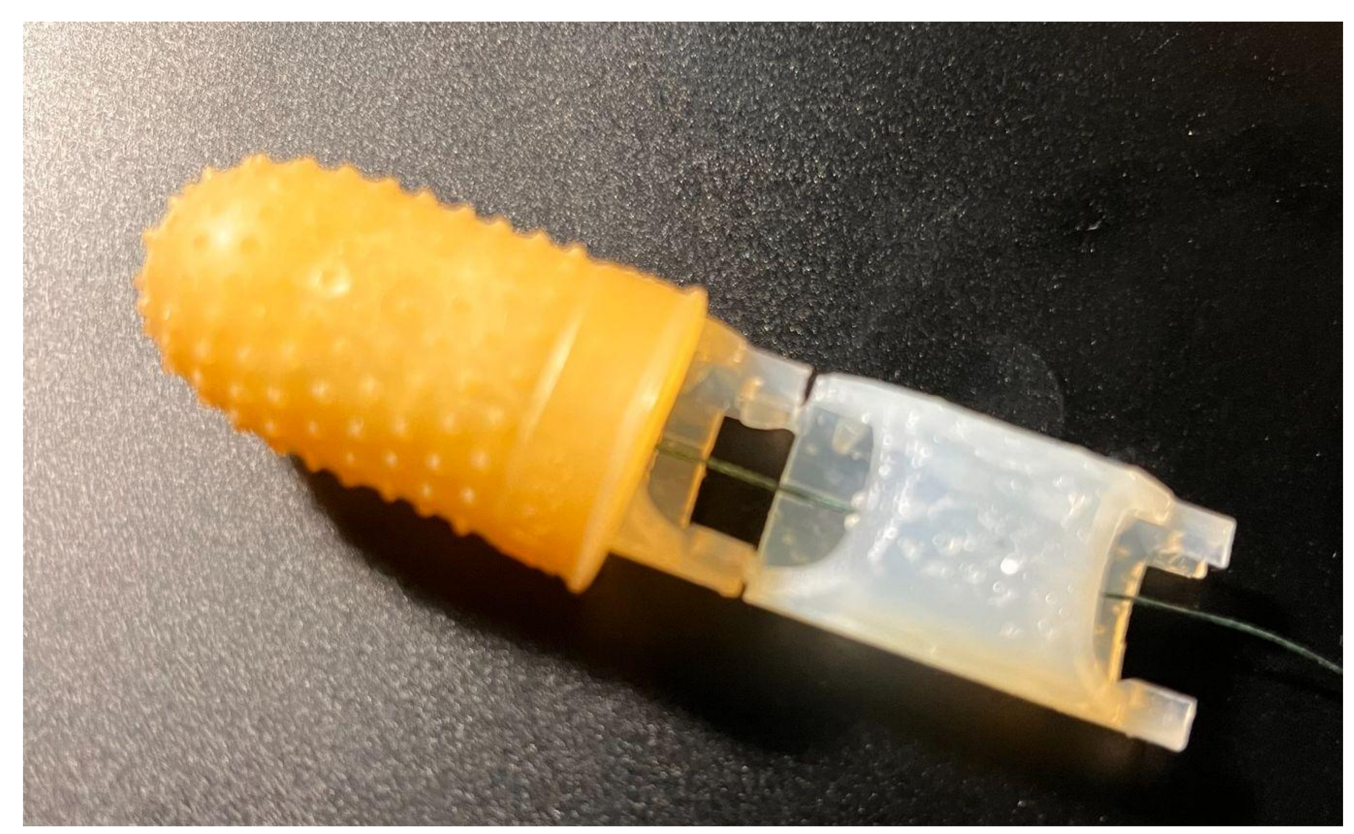
- Flexible Filament for joint manipulation
  - Utilizing elasticity to return fingers to an equilibrium state
  - Contraction → Release
- Finger Redesign
  - Snap fit assembly
  - Wiring
  - Complete movement
- Palm→Grip Strength
  - Research
  - Palm mobility and Grasp
  - Utilizing same flexible joints
  - Compression
- Pressure sensor for user feedback





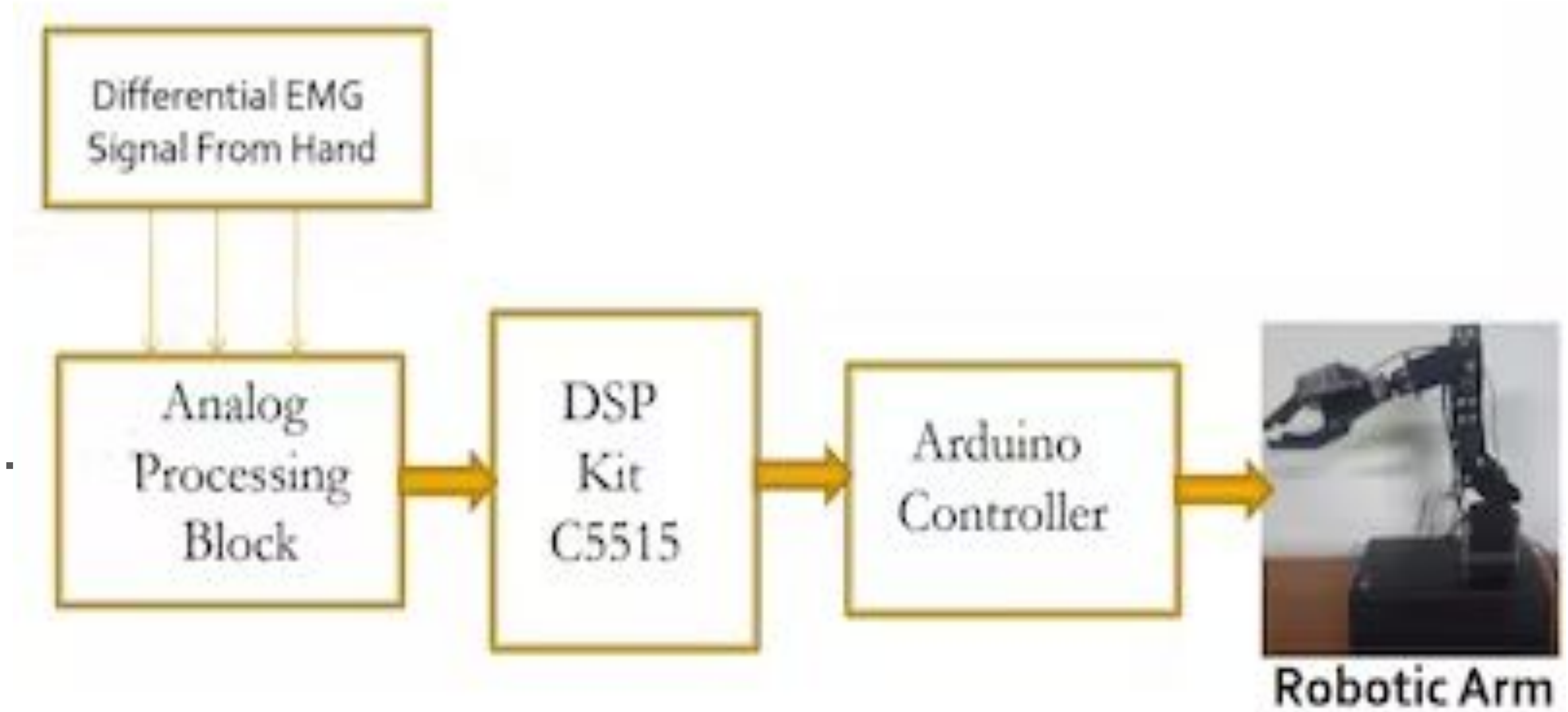






Future Goals

- Sensoring EMG Signal.
  - Electromyography (EMG) measures muscle response or electrical activity in response to a nerve's stimulation of the muscle.
- EMG Signal Processing:
  - Frequency ranges vary from 0.01 Hz to 10 kHz.
  - The most useful and important frequency ranges are within the range from 50 to 150 Hz



- Removal of Motion Artifacts for EMG
  - The significant interferences of the surface EMG signal are the motion artifacts
  - The EMG signal is also significantly influenced with the ECG signal
- The Adaptive Noise Canceler (ANC)
  - Based filtering can be successfully used for the purpose of the PLI or the ECG artifacts elimination
- ENG - Electroneurography,
  - Is a method used to visualize directly recorded electrical activity of neurons in the central nervous system (CNS)
- Bioprint artificial "skin"