Hardware Review

To: Dr. Sarah Oman

From: Prosthetic Hand (18S12)

Date: 2/22/2019

Re: Hardware Review 1

Cuff

This component of the arm is Felicity's responsibility. In *figure 1* the current model for the cuff and its motor and arduino attachments are shown. This design featured flexible boxes that should have rounded as the cuff was thermoformed. The pin attachment is adjustable for scaling and possible thermal deformation. Any unneeded pin holes could be removed from the length with pliers.

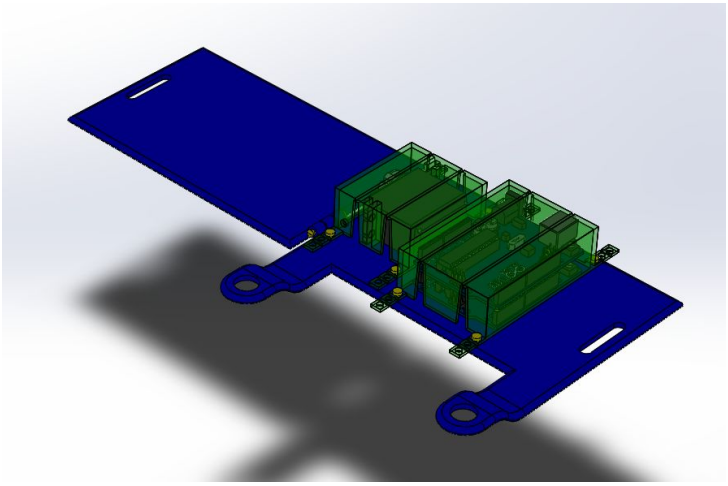

Figure 1: Current Cuff Design

The design did not function as intended as shown in *figure 2*. The electronics' boxes were not as flexible as originally thought and were not able to allow the pins to reach the holes. The holes were then stretched and the pin attachments were bent to see if a new attachment type could be made with little modification to the original design but the changes were found to be unsuitable and the cuff would need to be redesigned.

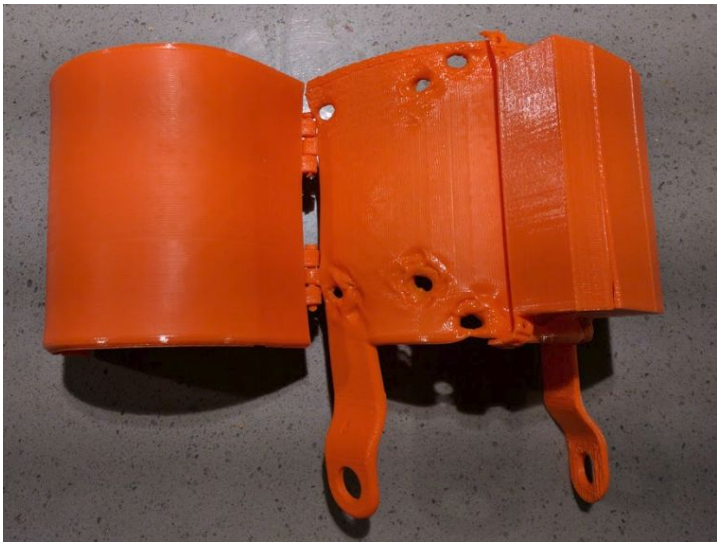

Figure 2: Current Cuff Printed

An additional cylinder was then printed to help with the understanding of orientation and the relative size of the electronics to the intended cuff size. *Figure 3* shows the thought process while brainstorming the new design. While using the makeshift cuff, it was found to be much stronger than originally thought for a part that was not thermoformed. Though thermoforming would be much stronger in multiple axes, an ⅛” print would be strong enough to not shear along the layer line for the intended arm weight of 5lbs. This means that the cuff can be printed “as is” and the electronic holders can be printed directly to the cuff.

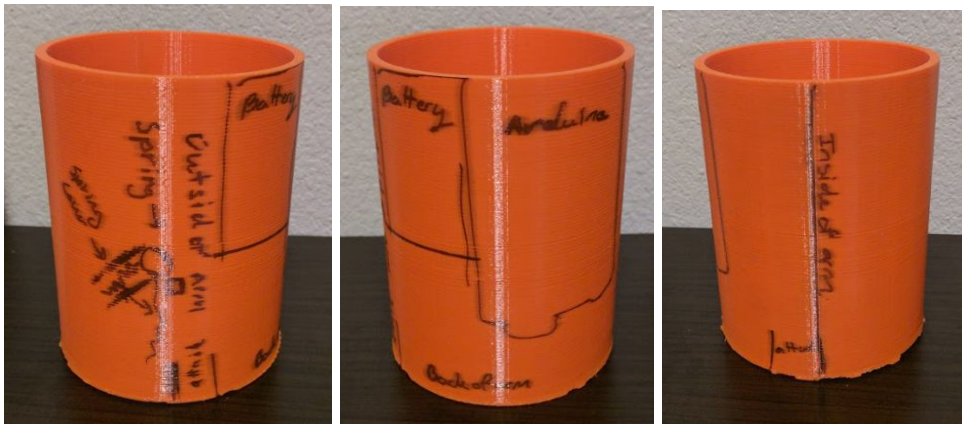

Figure 3: Recommended Changes Sketched around Cuff

The cuff will be redesigned using the suggestions shown in *figure 3* and will have a simpler and easier to assemble attachment for electronics. This means that the cuff will be thicker than hoped but better in design and aesthetics. The attachment for the cuff to the forearm will need to be discussed in detail and redesigned during our next team meeting. This redesign will include the spring assist and address motor wiring from the

forearm to the controller on the cuff.

Forearm

This component of the arm is Allison's responsibility. Physical components of the forearm printed by this review include the mold that the arm pieces will be thermoformed around (figure A#1) and the two forearm components, already thermoformed (figure A#2).

Figure A#1: Thermoforming Mold

Figure A#2: Thermoformed Arm Pieces

The forearm components could not fully wrap around the mold when thermoformed, meaning that they are too skinny. They need to be widened. Also to note, the number of hinges and clips on the arms was reduced to reduce the amount of variability when thermoforming. In order to attach the forearm to the cuff, material is extended with pin inserts on the back of the model. Attachments to the hand have not yet been incorporated into the design. An updated CAD model is shown in figure A#3.

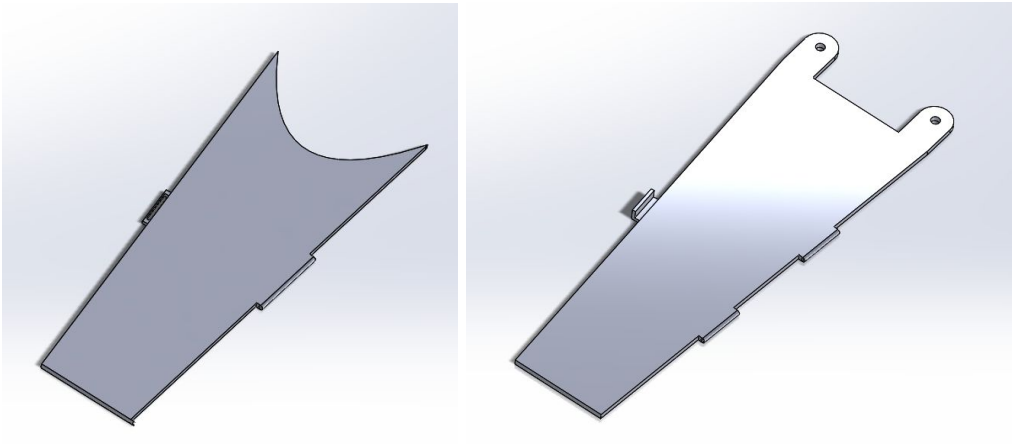

Figure A#3: Forearm CADs

A container for the motors should be placed inside the arm. This component's design has not yet been complete due to the size of the motors leading to design alterations. A CAD of the current progress of the container is in figure A#4.

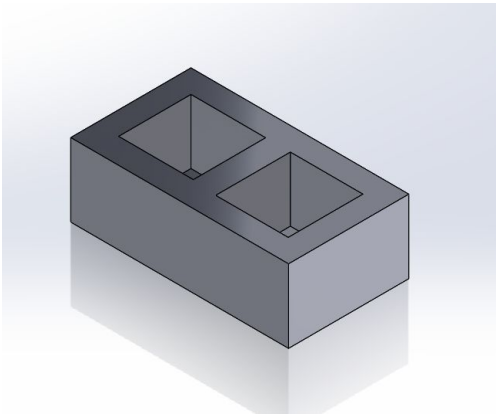

Figure A#4: Motor Compartment

After further discussion about how the motors should attach to the forearm, it was determined that a separate compartment should be designed for the motors to help reduce the influence of heat on the rest of the arm and the client. For this reason, more alterations will be made to the forearm design. These alterations are estimated to be splitting the forearm in half, with the back half being a hollow arm and the front half being the compartment for motors. It was also discovered that if the thickness of material is 1.8", curved surfaces are durable and shear is not a concern. For this reason, thermoforming will not be necessary to reduce shear and the forearm can be printed as one solid, round piece. These alterations will be made before hardware review 2.

Hand

Antoinette is responsible for the palm component of the arm. The palm was made with the intention of having a functional but aesthetically pleasing design. Therefore, this palm was modeled after one of the team members. The palm includes two parts: the palm bottom that holds the wires and the motors and the cover that will close over them for protection. Figure h4 shows this completed palm in CAD design so far.

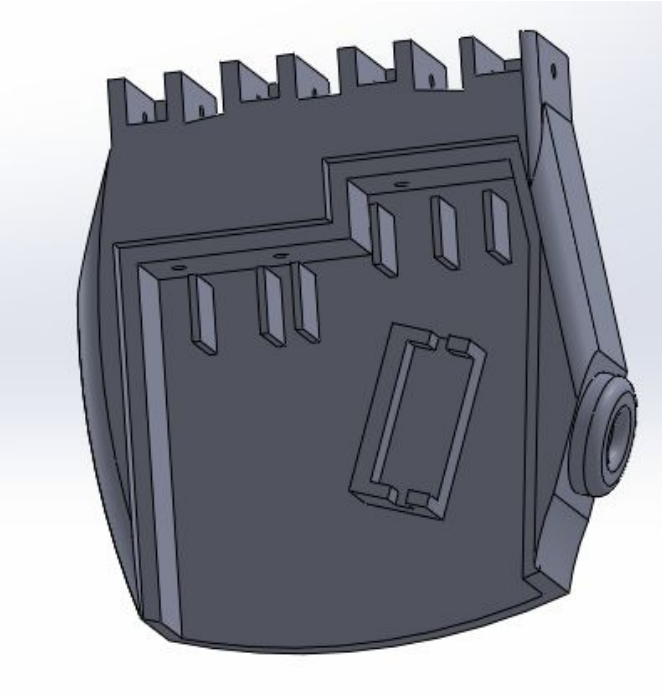

Figure h1: Palm Bottom

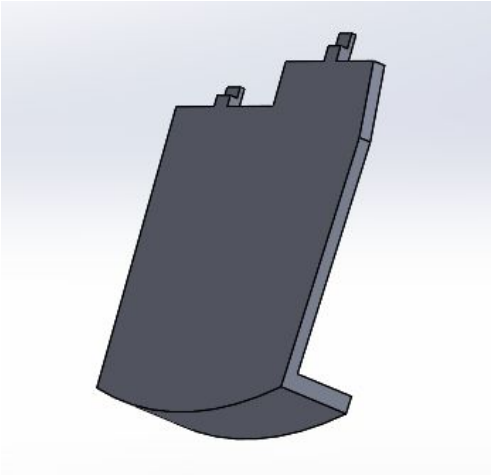

Figure h2: Palm Top

The goal for the palm is to be able to accommodate the movement of 4 fingers as well as full mobility of the thumb finger. This thumb, controlled by the two big toes of the foot, would allow the thumb to move back and forth as well as left to right. The palm would need to incorporate a motor to allow for full mobility. This motor will be a vilros microserve motor approximately an inch or so in length. Below shows a figure of this motor. Because of its smaller size and light-weight, it should be no problem for the client to be able to lift this palm and fingers. The other fingers should have enough mobility to move up and down but the design will prevent them from moving too far out, preventing them from possibly breaking from the strain.

Figure h3, Motor Attachment for the Arm

Installation for the user should be simple due to the small grooves in the palm. The opening was made as large as possible for an easier insertion of the wires and motors. The finger connections will include the same pins used in other parts the arm as well as modified ones so the hand can move from fully opened to fully closed.

Because of technical difficulties with the 3D printer, the palm was not able to be printed in time for this hardware review or for the closing component to be tested. If this cannot be fixed, the palm will be printed in the maker's lab at the Cline library after the storm. Below shows the results of attempting to print the arm. It is likely that the cold temperatures from the storm ruined the printing job and prevented the part from

being made.

Figure h4: ruined 3D Printed Job

Because the individual analysis will discuss the type of hinges and connections that will be the best for the arm, the palm design will likely be modified for the palm top. The bottom will also be modified to be able to attach to the forearm but it will not need a full 360 degree rotation. Even with the bad attempt at printing the palm, the printing can still move in a timely manner.

Fingers

Jannell is responsible for the finger components of the arms. The five fingers are composed of a proximal and distal section that are connected by a hinge joint. Digits 2-4 (pointer finger through pinky) all have the same basic design, however the dimensions are changed for the respective finger. The distal finger is attached to the proximal via a pin that passes through holes in both. This creates a hinge that lets the finger bend. Similarly, the proximal section of digits 2-5 attaches to the palm. In addition, the proximal and distal parts have channels across their top and bottom. These holes are for the artificial tendons to travel through. The tendons will be attached to motors that will pull the tendons and flex the fingers. The 3-D printed assembly can be seen in Figure J#1. Unfortunately, the print of the finger broke when being removed from the printer's raft. In addition, the hinge did not fit together due to incorrect tolerances. These issues will be fitted before the next hardware review.

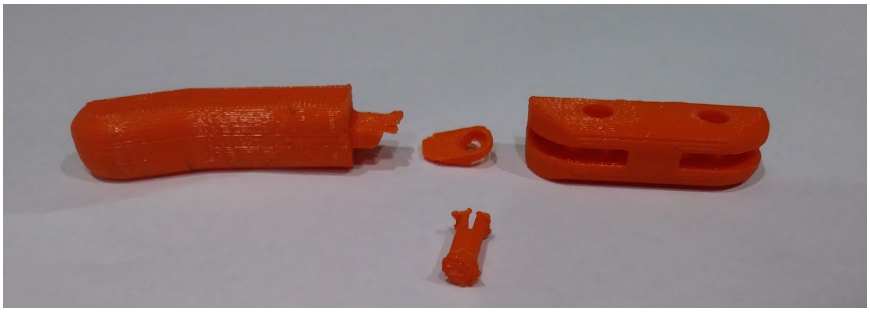

Figure J#1: Print of Digit 2 (dimensions vary for digits 2-4)

The assembly of these digits can be seen in Figure J1 in the Appendix. The hinge pin, the proximal digit, and distal digit CAD can be viewed in Figures J2, J3, and J4 in the Appendix.

The design for digit 1, the thumb, is slightly different. The distal and proximal sections are still the same design as the other fingers. However, the proximal section of the thumb attaches to a rotating base rather than directly to the palm. The rotating base, that is attached to the palm, will allow the thumb additional range of motion and will be controlled by an additional motor.

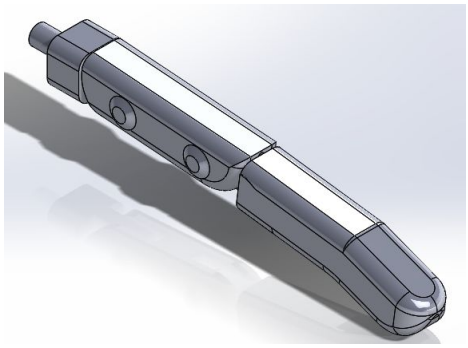

Figure J#2: Assembly of Digit 1

The pins that create the hinge between each section of the finger are held in place due to their unique design. The pin has a shot slit horizontally cut though it. This allows the pin head to be pinched and fit through the holes in the proximal and distal sections. Once the head reaches the other side, the head will unpinch and will hold the pin in place. The pin can be seen in Figure J#3 below.

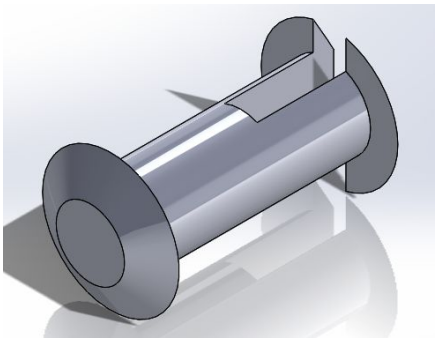

Figure J#3: Finger Hinge Pin

There are some changes that need to be made to these designs before the next hardware check. The fingers will be widened to improve strength, the tolerances will be changed so the printed hinge will fit together, and the tendon channels will have a larger diameter.

Code

Allison and Felicity have been working on code for wireless communication as well as actuation. As of right now, the code only works to get two XBEEs talking to each other, without sending data across. The materials used for the wireless communication are an arduino uno with an XBEE shield and XBEE Series 1 as the transmitter, with an XBEE Series 1 as the receiver. The assembly is shown in figure A#.

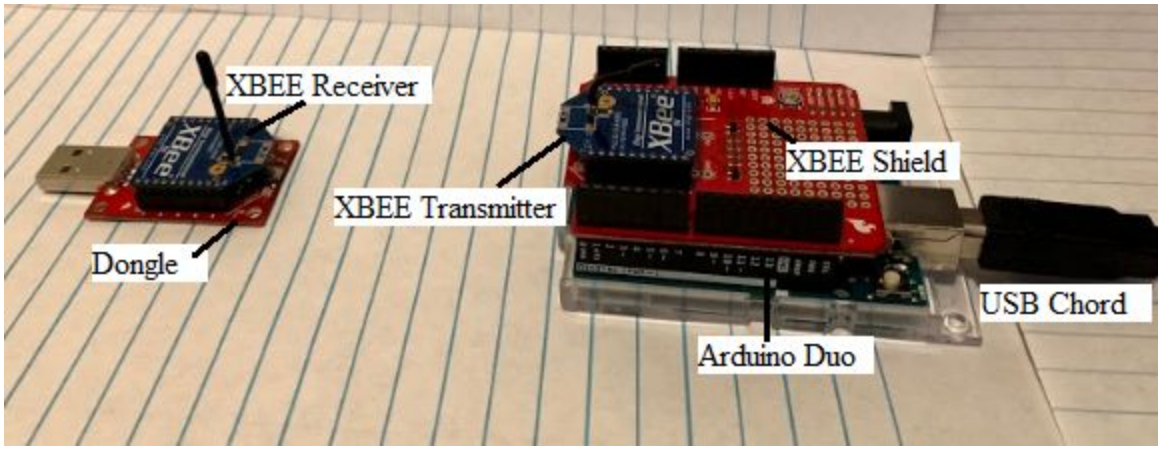

Figure A#: XBEE-Arduino Wireless Communication Assembly

Future Work

To summarize the future work as stated above, the forearm will be redesigned to consist of two halves: a hollow forearm piece and a compartment for the motors.

These halves do not need to be thermoformed if they are printed at ⅛” thickness, so the design will be a solid component already in a rounded shape. The palm still needs t be printed via the makers lab to test the top attachment. The attachments between each section of the arm still need to be discussed in detail and possibly redesigned. Six motors, the lithium battery and charger, and the servo shield must be ordered once confirmed with the EE team on Monday. Once the electronic components are confirmed the PID control code can be fished.

Appendix

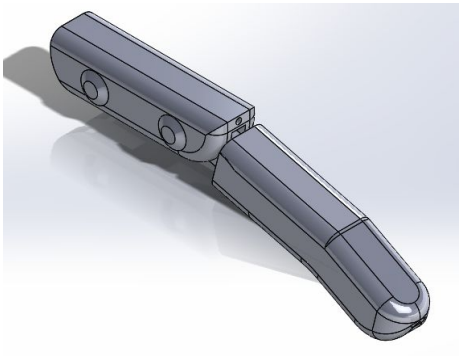

Figure J1 Assembly of Digits 2-5 (dimensions vary for respective digits)

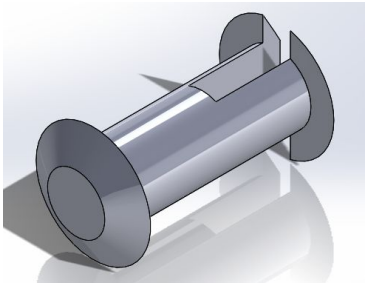

Figure J2 Finger Hinge Pin

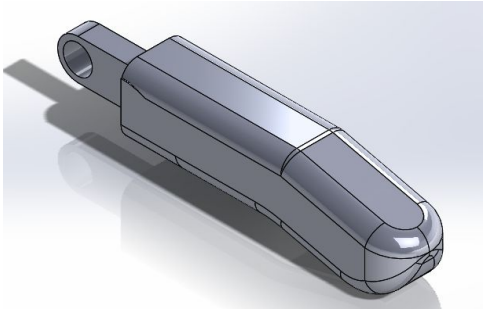

Figure J3 Proximal Section of Digits 2-5 (dimensions vary for respective digits)

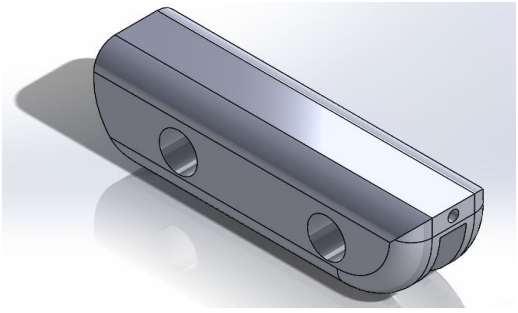

Figure J4 Distal Section of Digits 2-5 (dimensions vary for respective digits)

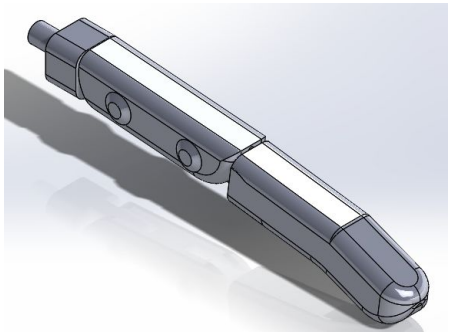

Figure J5 Assembly of Digit 1

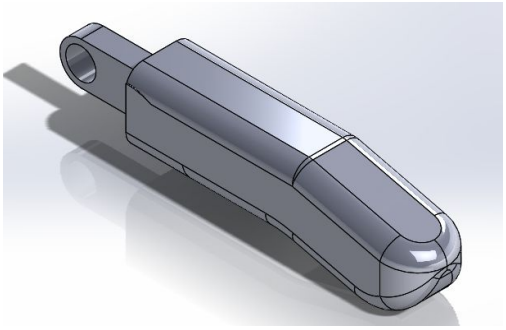

Figure J6 Proximal Section of Digit 1

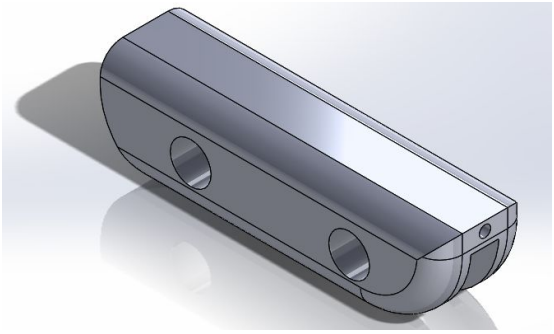

Figure J7 Distal Section of Digit 1

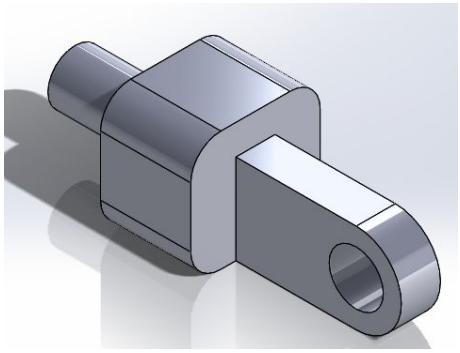

Figure J8 Rotating Base of Digit 1