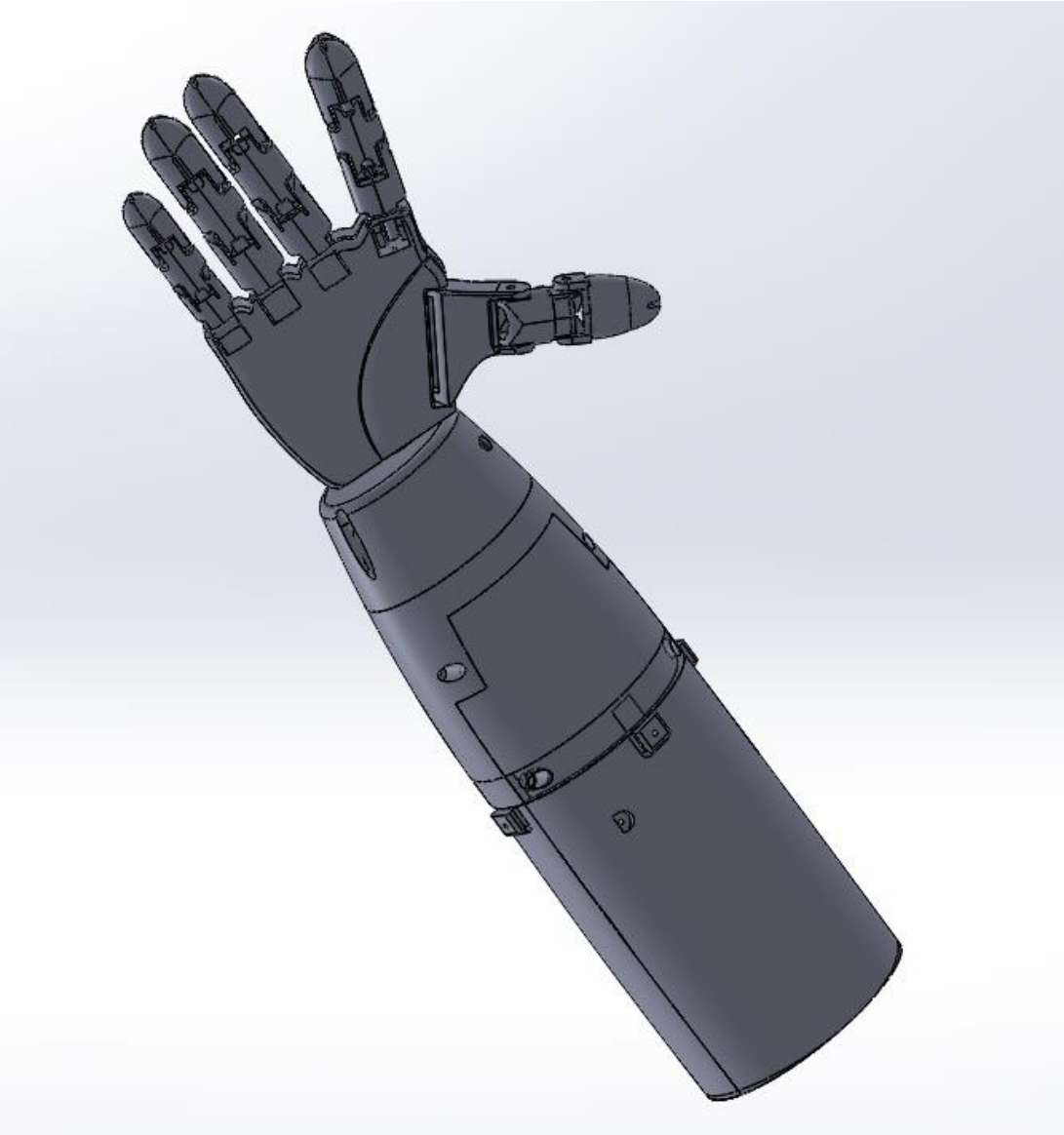
Arduino-controlled Prosthetic Forearm Assembly Guide Version 1.0

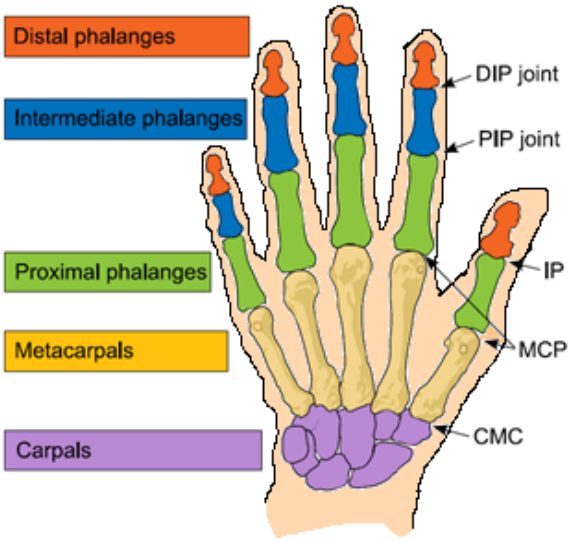


Design and assembly guide generated by Tasnim Ahmed. For more info, visit: https://github.com/tasnim04/Robotic-Prosthetic-Arm-

Assembly guidelines:

- ## Finger assembly

The prosthetic forearm shares a similar structure to the human hand. A human finger comprises of three joints – distal, intermediate, and proximal. This prosthetic forearm design aims to replicate these three joints. Three separate sections have been 3D printed for each finger which resemble the joints. 3D printed snap-fit rivets will be used to attach all the three sections together. The unassembled and the assembled pictures for the five fingers are as follows.



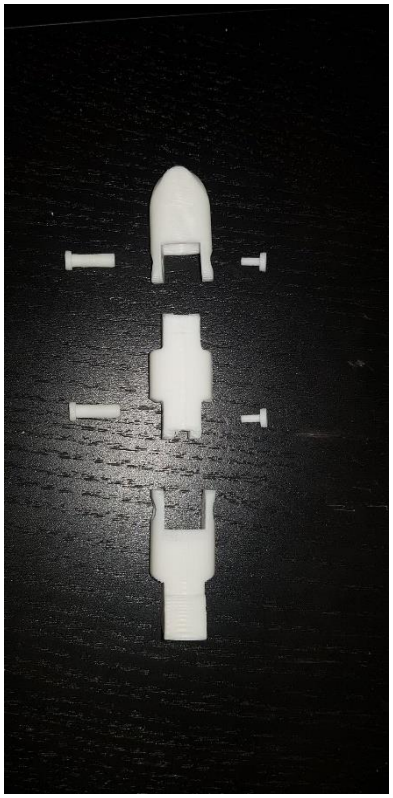


Figure : Unassembled middle finger.

Figure: Assembled middle finger.

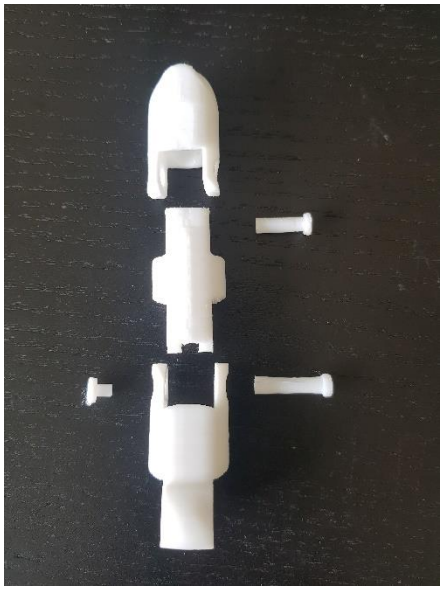


Figure : Unassembled index finger.

Figure: Assembled index finger.

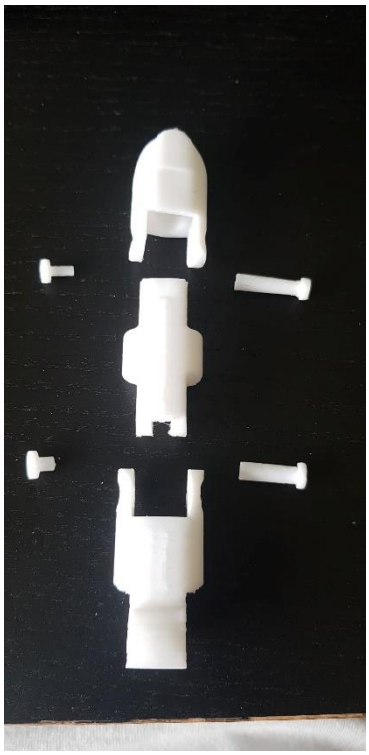


Figure : Unassembled ring finger.

Figure: Assembled ring finger.

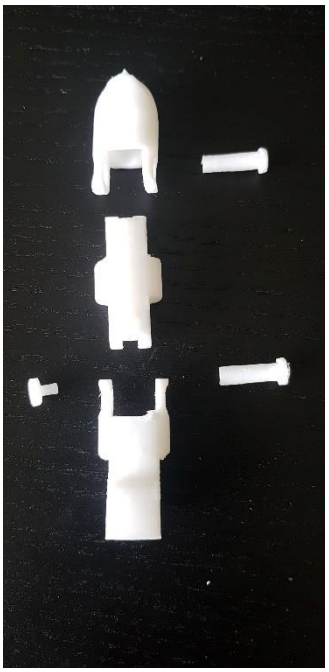


Figure : Unassembled pinky finger.

Figure: Assembled pinky finger.

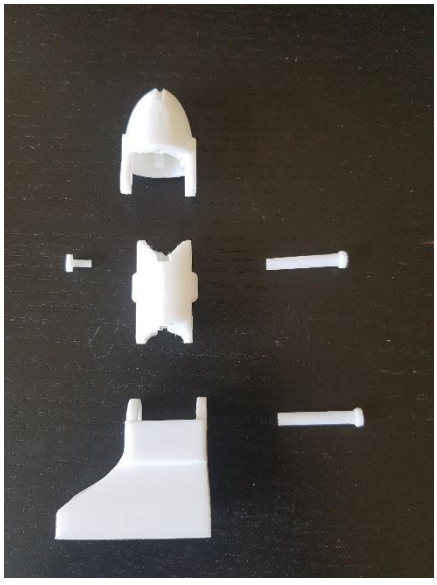


Figure : Unassembled thumb finger.

Figure: Assembled thumb finger.

- # Nylon wiring

In order to achieve the desired grip patterns outlined in this documentation, 0.6mm nylon fishing line will be used. The physical properties of the nylon fishing line make it an ideal material to serve as tendons for the prosthetic forearm. These fishing lines pass through small guide holes present in the fingers, forearm, and servo gearheads, in order to actuate the fingers. The nylon wiring guidelines are been divided into 4 parts –

- Fingers
- Palm
- Forearm
- Servo gearhead.

Special care must be taken to ensure the nylon fishing lines do not tangle with one another. This could potentially affect the tension between the finger sections, causing the grip pattern to become unachievable.

- ## Finger wiring

  All the fingers have two small guide holes for the purpose of passing nylon fishing lines through them. The thumb and the middle finger will be used to illustrate the guide holes, and how to pass the nylon fishing lines. The wiring of the middle finger is similar to the index, ring and pinky fingers.

Figure: Top-section holes

Figure: Middle-section holes

Figure: Bottom section holes

Pass two separate nylon lines through the two guide holes. Start with the top section which contain the fingernails. Remember to tie a knot between the two nylon lines at this top section. Ensure the knot is large enough and does not pass through the nylon guide holes.

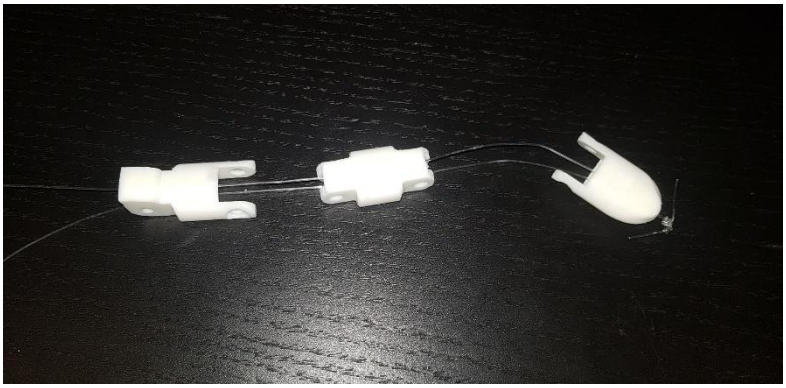


Figure: Middle finger after nylon fishing lines passed through

Next, test if the two nylon lines are correctly contracting and relaxing the fingers. Upon pulling the front nylon line (as illustrated below), the finger should move fully contract. Upon pulling the other nylon line (refer to figure), the finger should move to its original resting position.

Figure: Relaxation (when back nylon pulled)

Figure: Contraction (when front nylon pulled)

The index, middle, ring and pinky all share the same mechanism for contraction and relaxation when the respective nylon lines are pulled. For reference, the index finger's contraction and relaxation position are as follows.

Figure: Relaxation (when back nylon pulled)

Figure: Contraction (when front nylon pulled)

The structure of the thumb design is different to the other fingers. The two guide holes are also present on each of the thumb sections to pass the nylon fishing lines.

Figure: Top-section holes

Figure: Middle-section holes

Figure: Bottom-section holes

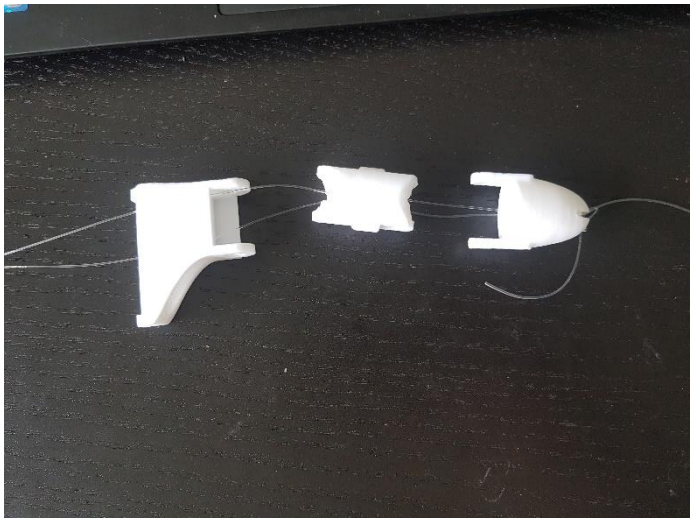


Figure: Thumb after nylon fishing lines passed through

Make sure to check the contraction and the relaxation of the thumb by pulling the two inserted nylon lines in the same way as instructed earlier.

Figure: Relaxation (when back nylon pulled)

Figure: Contraction (when front nylon pulled)

Once the fingers have been fully assembled, proceed onto the palm. An overview of how the fingers should be positioned along with the palm is as follows.

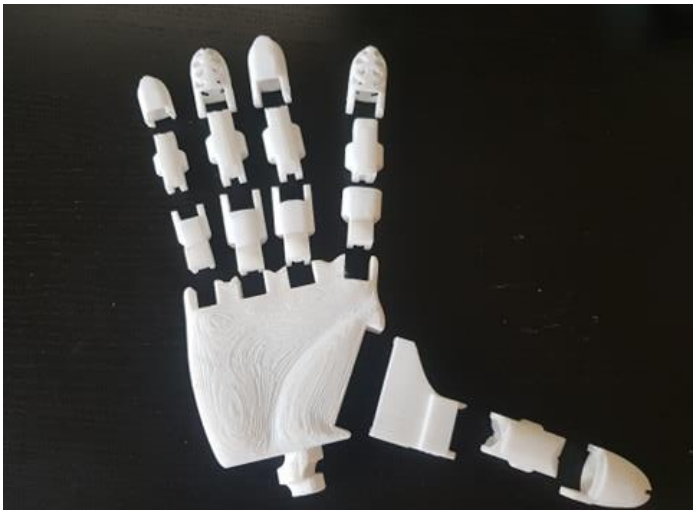


Figure : 3D printed finger parts (version 1)

○ Palm assembly & wiring

Each finger slot for the palm has two guide holes, designed to pass the two nylon lines from each finger. The bottom of the palm has 5 additional guide holes which will be used to pass the nylon lines into the forearm.

Figure: Palm with the guide holes

The palm also has circular slots on the sides of the finger beds, in order to pass nails and hold all the fingers in place.

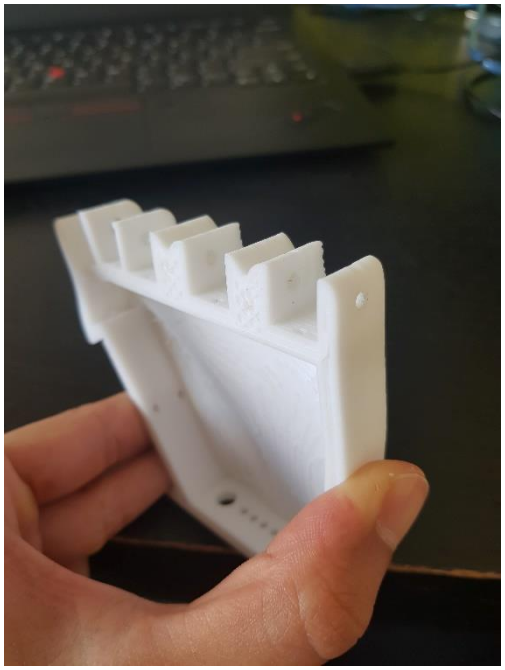


Figure: Palm with holes attachments

Figure: Palm with hole attachments (alternate view)

One snap-fit rivet has been used to attach the index finger to the palm. Two large pins have been used to attach the other four fingers (thumb, middle, ring, pinky).

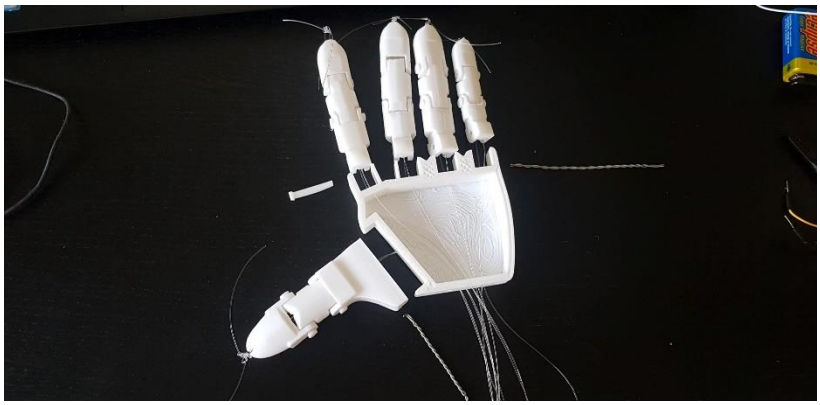


Figure: Palm and fingers (unassembled)

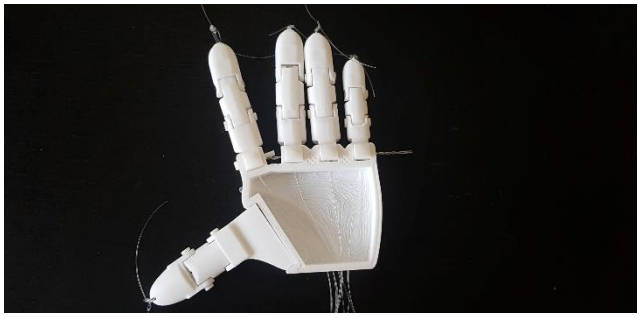


Figure: Palm and fingers (full assembled) - fingernails

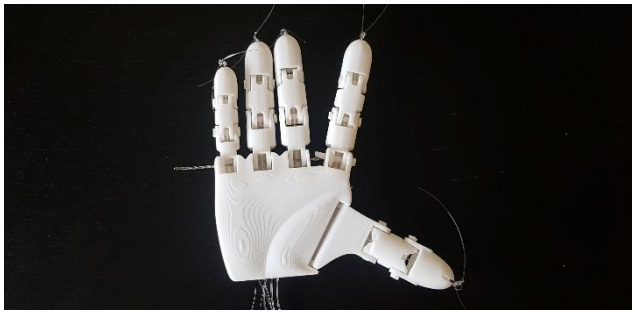


Figure: Alternate view

It is important to ensure that the direction of all the fingernails is corresponding with the empty hollow side of the palm (observe figure on the left). All the fingers should contract towards the closed end of the palm (observe figure on the right). For further clarification, refer to the figure below.

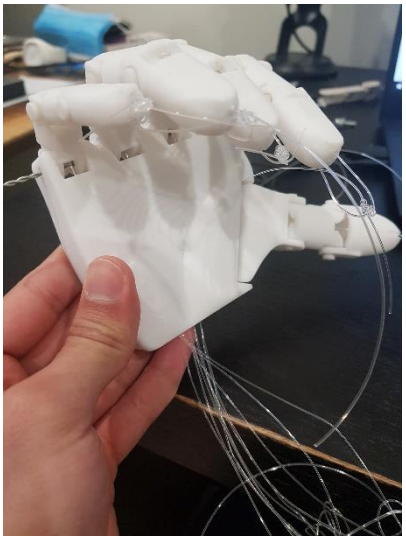


Figure: Contracted fingers with palm

○ Servo gearhead wiring

The nylon fishing lines will be pulled by the servos. The servos come with circular gearheads which can be attached to the gear and screwed in securely. These circular gearheads were drilled to create small holes.

Figure: Servo gearhead (drilled)

Nylon fishing lines were passed through these holes and secure with knots. It is important to ensure the nylon lines do not start to get loose. This will result in loss of tension, which will result in poor actuation of the fingers.

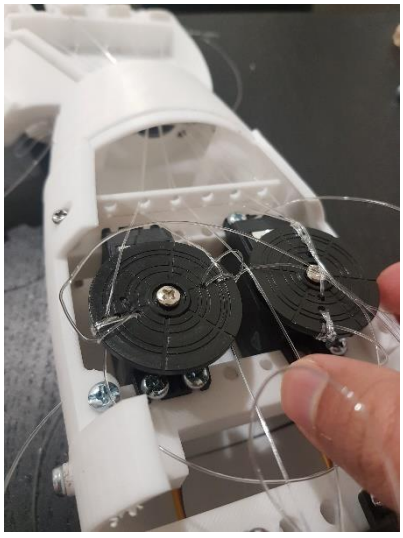


Figure: Servo gearheads attached to servos and securely tied to nylon fishing lines

As the servos rotate about 180 degrees, the respective nylon fishing lines will be pulled, resulting in the contraction and/or relaxation of the fingers. For more info, refer to the programming section and the video demonstration.