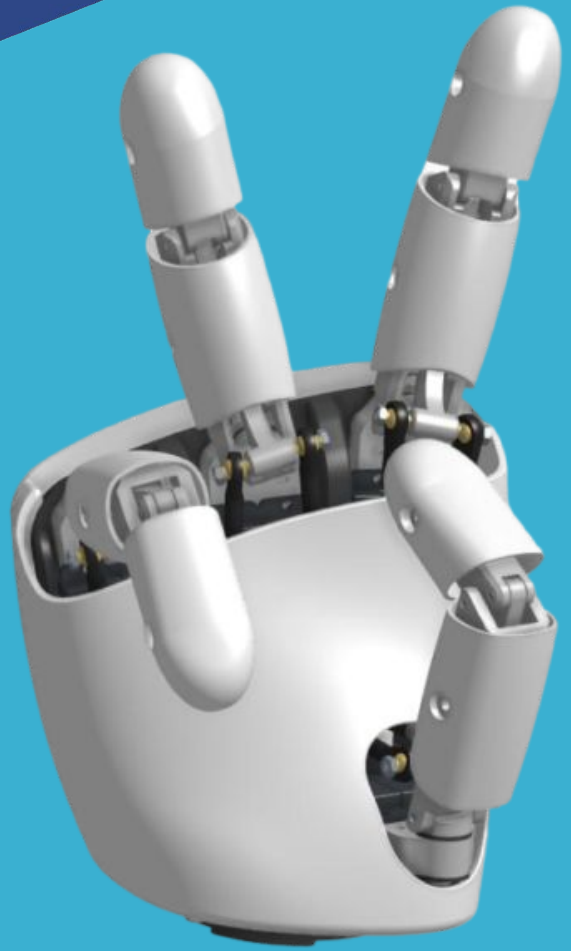
POLLEN ROBOTICS

Amazing Hand

8 dofs humanoid hand
Expressive
Open source

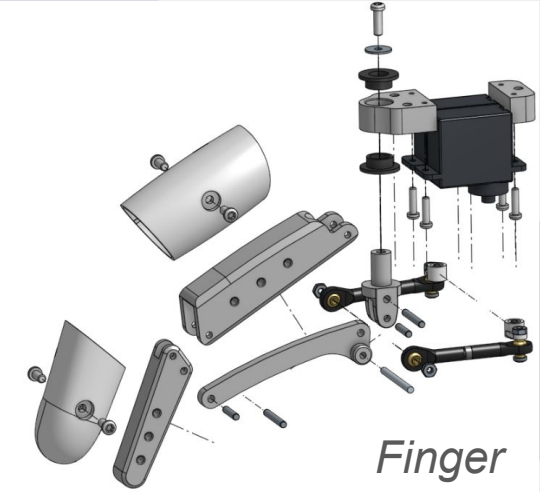


Pollen Robotics SAS
Bordeaux, France

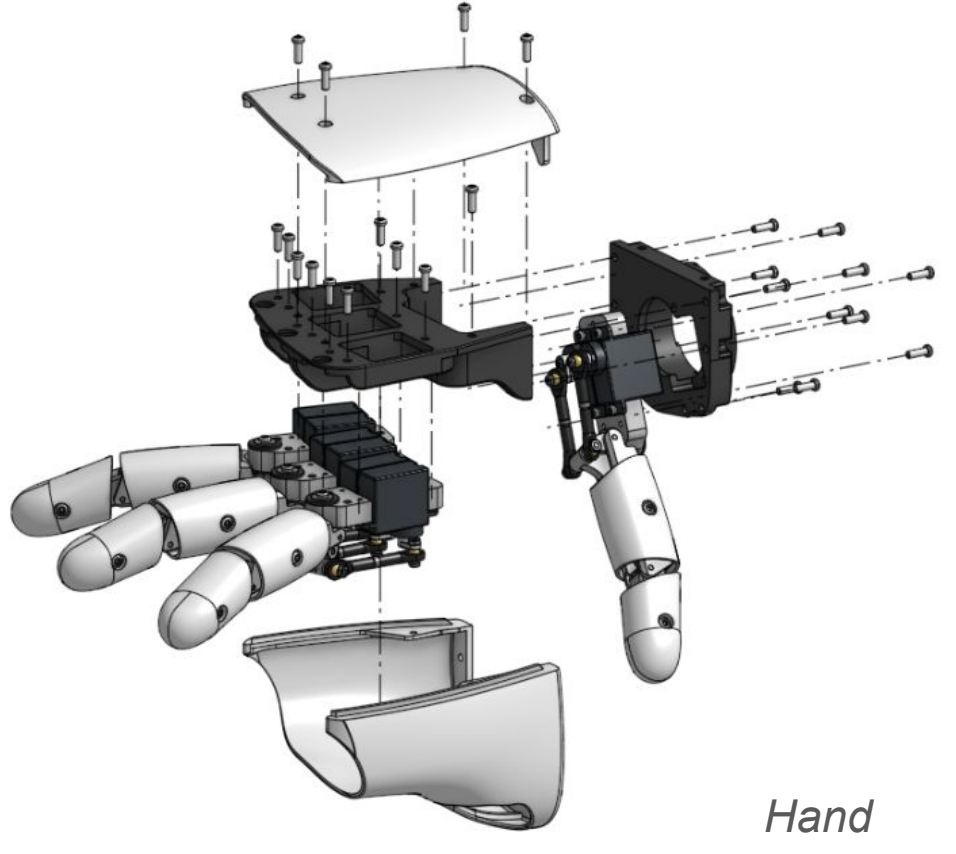
List of 3D printed parts

3D printing parts	Material	Quantity	Details
Finger Frame1	PLA	4	
Finger Frame2	PLA	4	
Proximal	PLA	4	
Distal	PLA	4	
Gimbal	PLA	4	
Link	PLA	4	
Hand Plate	PLA	1	
Wrist Interface	PLA	1	
Proximal Shell	Flex	4	Filaflex 82A or Esun TPA 83A
Distal Shell	Flex	4	Filaflex 82A or Esun TPA 83A
Soft Shell	Flex	1	Filaflex 82A or Esun TPA 83A
Top Shell	Flex	1	Filaflex 82A or Esun TPA 83A

See "AmazingHand_3D printing tips" document for more details



Finger x4



Hand

Summary

Needed tools

Step 1 : Preparing components
- ★ Mechanical components needed for finger assembly
- ★ Reworking standards parts
- ★ Reworking custom plastic parts

Step 2 : Finger assembly
- ★ Ball joint rod
- ★ Servo horn
- ★ Finger mechanism
- ★ Finger shells
- ★ Bushings
- ★ Actuator
- ★ Finger final assembly

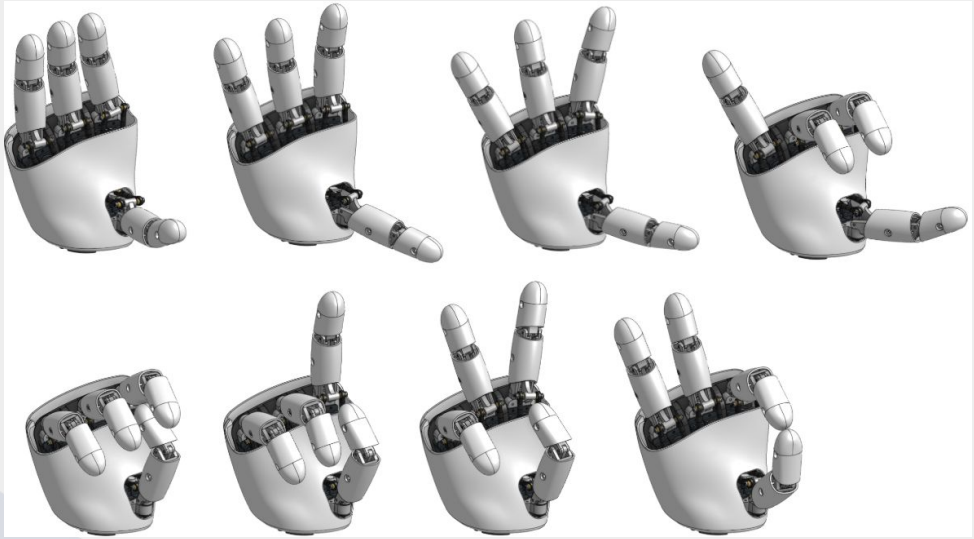
Step 3 : Finger calibration with Python
- ★ Setting IDs
- ★ Fine tuning

OR

Step 3 : Finger calibration with Arduino
- ★ Setting IDs
- ★ Fine tuning

Step 4 : Hand assembly
- ★ Fingers mounting
- ★ Thumb mounting
- ★ Hand assembly

Step 5 : Shells assembly



Needed tools

- ϕ1.5 drill bit
- ϕ2 drill bit
- M2 tap
- Cross screwdriver (PH0)
- Flat pliers
- Scalpel (or thin cutter)
- Dremel with abrasive disk (or strong cutting pliers)
- Portable drill

Step 1 : Preparing components

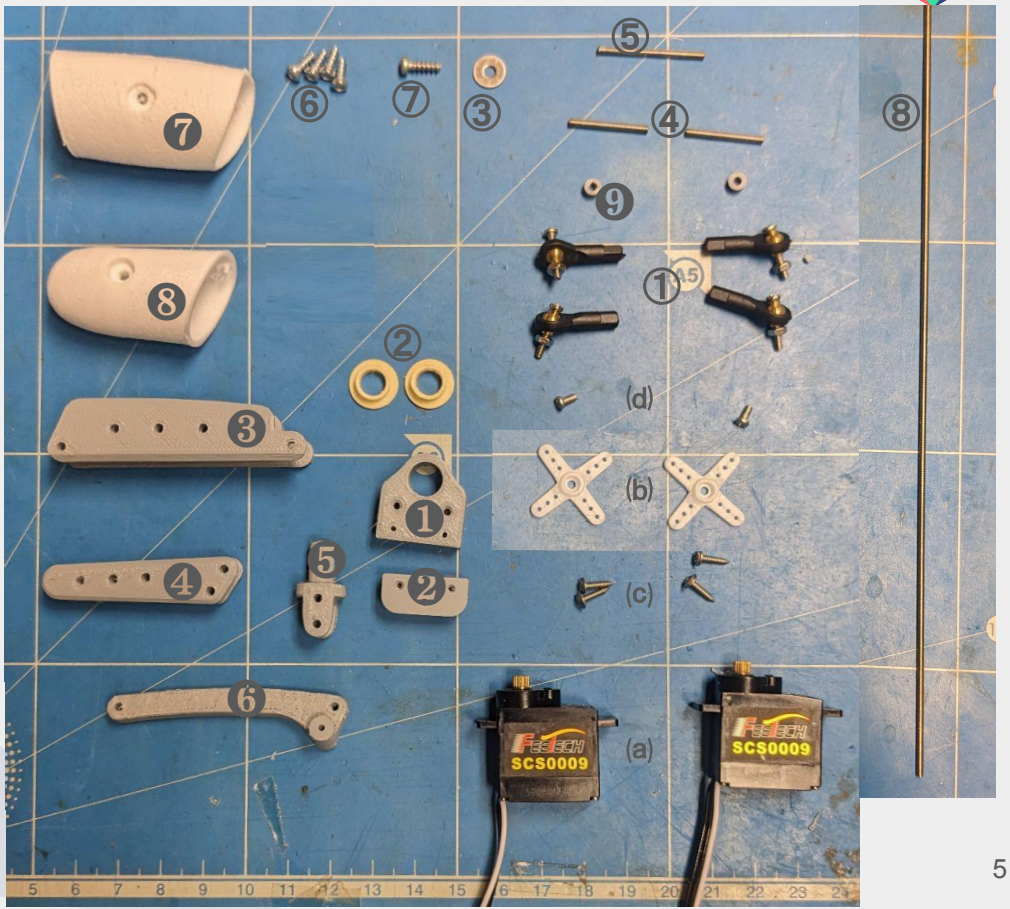
★ **Mechanical components needed for finger assembly :**

Custom plastic parts needed :
- (1) *1x* Finger frame part1
- (2) *1x* Finger frame part2
- (3) *1x* Proximal
- (4) *1x* Distal
- (5) *1x* Gimbal
- (6) *1x* Link
- (7) *1x* Proximal shell
- (8) *1x* Distal shell
- (9) *2x* Spacer

Standard parts needed :
- (1) *4x* M2 Ball joint *(comes with M2x12 screw and M2 nuts)*
- (2) *2x* Bushing D interior 6
- (3) *1x* M2.5 large washer
- (4) *2x* Axis D2x10
- (5) *2x* Axis D2x16
- (6) *4x* Thermoplastic screw 2.5x6
- (7) *1x* Thermoplastic screw 2.5x8
- (8) *1x (or 2x)* M2 threaded rod L300 mm

Actuator parts needed :
- (a) *2x* Feetech SCS0009
- (b) *2x* Cross servo horn
- (c) *4x* Servo 2x7 screw
- (d) 2x Servo M2x4 screw

All comes with SCS0009 package

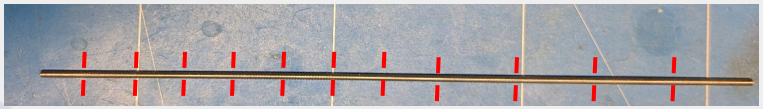


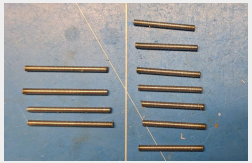
Step 1 : Preparing components

★ **Reworking standard parts :**

- ***1x (or 2x)*** M2 Threaded rod

=> cut the M2 threaded rod to obtain : - **4x** M2 Threaded rod **L25mm minimum (L28 maximum)**
- **8x** M2 Threaded rod **L18mm maximum (L15 minimum)**





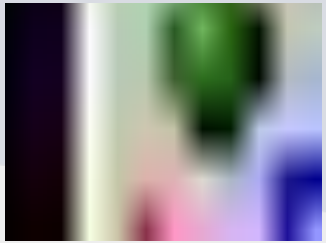
Tips : You may have to keep nuts on screw before cutting it, as well the nut will smooth the threaded when you retire it after cutting.

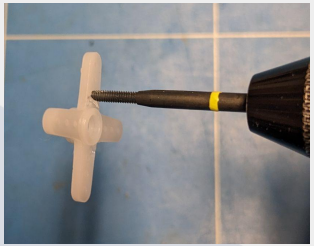
- ***8x*** M2 ball joint screw **L12mm**

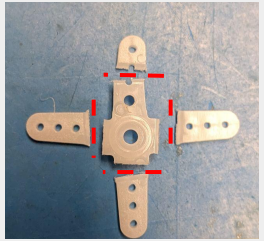
=> cut the M2 ball joint screw L12mm to obtain **8x screw L9mm**.

- ***8x*** cross servo horn

=> drill with ϕ1.5mm one of the hole which is closest to the center, make a M2 thread with tap (or a screw), cut useless branches of horn and finally smooth it to obtain **8x Custom servo horn**







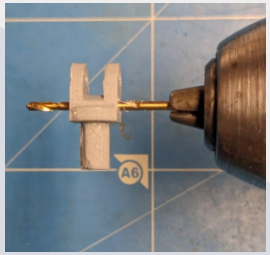
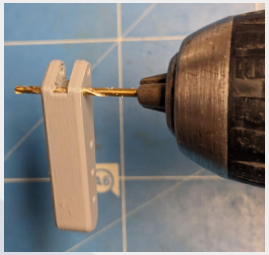
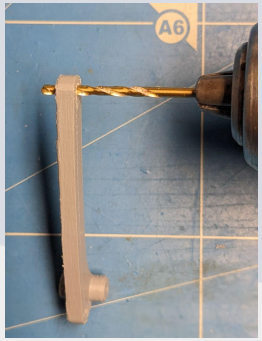
Step 1 : Preparing components

★ **Reworking custom plastic parts :**

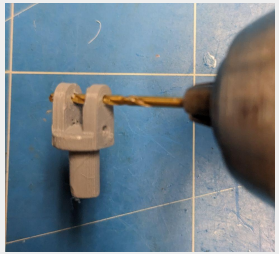
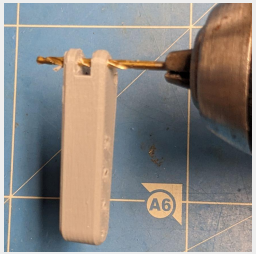
- ***24x*** D2 holes on Proximal / Distal / Gimbal & Link parts

ϕ2mm holes on 3D printed parts are not exactly at good size after printing (+ depends of 3D printer)
To ensure less friction as possible on the finger pivots while minimising functional gap, part of holes need to be sliding, and the other part tight.

Drill following holes to be sliding (/!\ without too much gap) :
(several back and forth should be necessary)


Drill following holes to be tighten : (1 back and forth should be enough)

Step 1 : Preparing components

★ **Reworking custom plastic parts :**

- Printed with support surfaces

All surfaces obtained by support will have to be cleaned and smoothed

examples :

As all 4 fingers are identical, you can try for a first one, and duplicate what you have to do for others

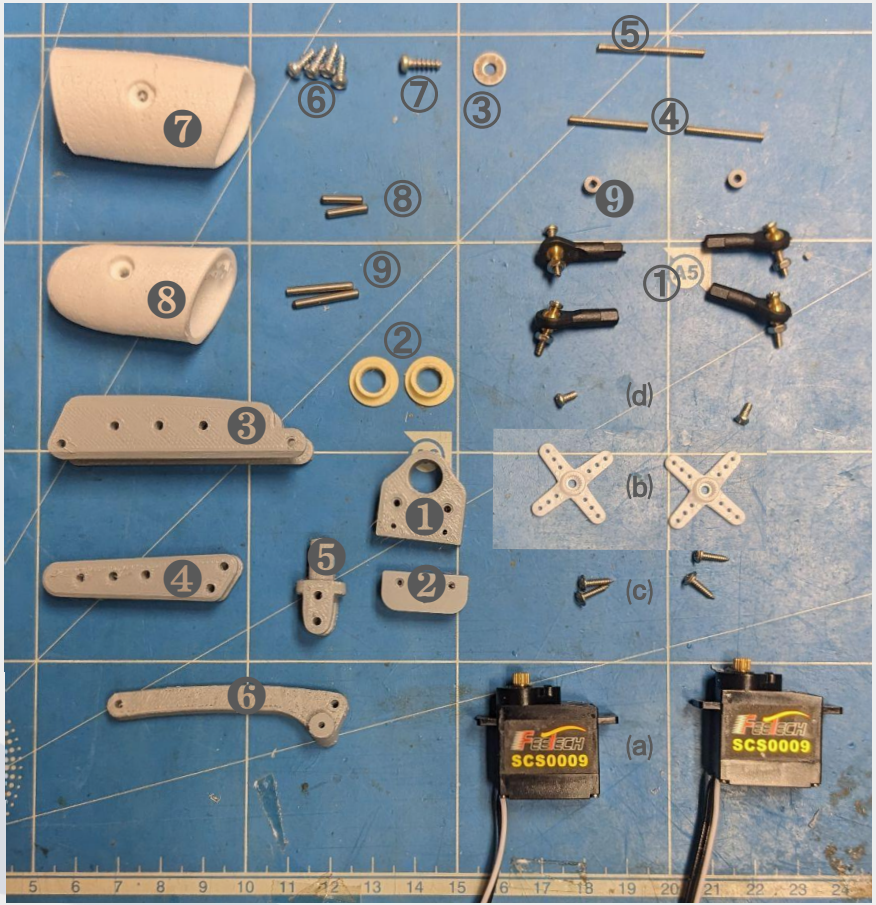
Step 2 : Finger assembly

★ **Mechanical components needed for finger assembly :**

Custom plastic parts needed :
- ❶ *1x* Finger frame part1
- ❷ *1x* Finger frame part2
- ❸ *1x* Proximal
- ❹ *1x* Distal
- ❺ *1x* Gimbal
- ❻ *1x* Link
- ❼ *1x* Proximal shell
- ❽ *1x* Distal shell
- ❾ *2x* Spacer

Standard parts needed :
- ❶ *4x* M2 Ball joint (**included 2x reworked screws**)
- ❷ *2x* Bushing D interior 6
- ❸ *1x* M2.5 large washer
- ❹ *2x* Axis D2x10
- ❺ *2x* Axis D2x16
- ❻ *4x* Thermoplastic screw 2.5x6
- ❼ *1x* Thermoplastic screw 2.5x8
- ❽ *2x* M2 threaded rod **L18mm**
- ❾ *1x* M2 threaded rod **L25mm**

Actuator parts needed :
- (a) *2x* Feetech SCS0009
- (b) *2x* Servo horn (**2x reworked**)
- (c) *4x* Servo 2x7 screw
- (d) 2x Servo M2x4 screw



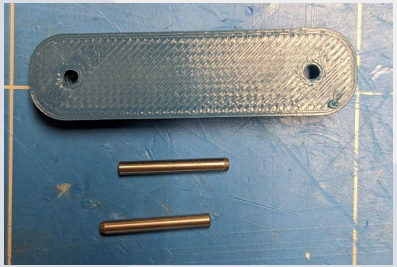
Step 2 : Finger assembly

★ **Ball joint rod :**

/!\ Ball joint rod is a critical components for the finger, which will ensure correct range of motion according to servo horn rotation.
Specific toolings is designed to help setting the good dimension

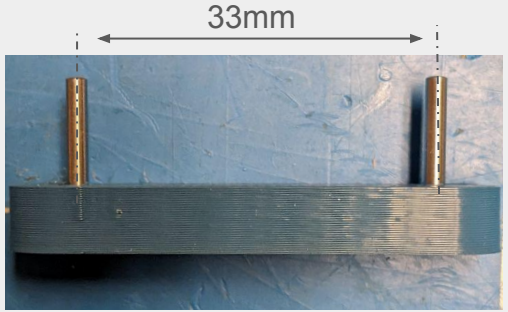
<u>Assembly of toolings :</u>

Parts needed :
- *1x* Length tooling
- *2x* Axis D2x16mm



First drill the 2x ϕ2mm hole, they should be tighten (refer to previous step)
Start pushing both axis into the holes

Finish pushing them until they are completely pushed through the plastic part



Step 2 : Finger assembly

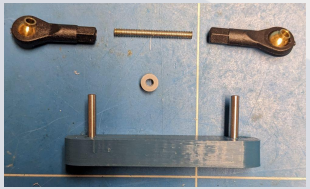
★ Ball joint rod :

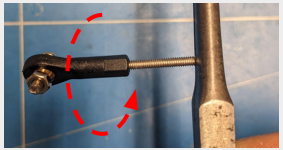
/!\ Ball joint rod is a critical components for the finger, which will ensure correct range of motion according to servo horn rotation. Specific toolings is designed to help setting the good dimension.

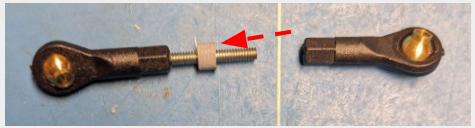
Assembly of ball joint rods :

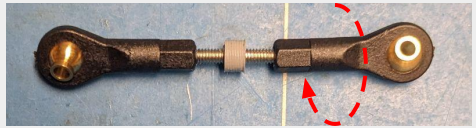
Parts needed :

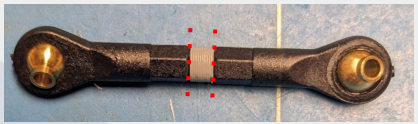
- *2x* M2 Ball joint
- *1x* M2 threaded rod **L18mm**
- *1x* Spacer
- *1x* Length tooling assembled











X2

Start screwing one ball joint with the threaded rod until it becomes harder (be aware to not damage thread of rod if you need to pinch it).
Note : if screwing into ball joint hole is not easy, you may use a M2 Tap to help creating filet inside the ball joint hole, or heat the rod a little).

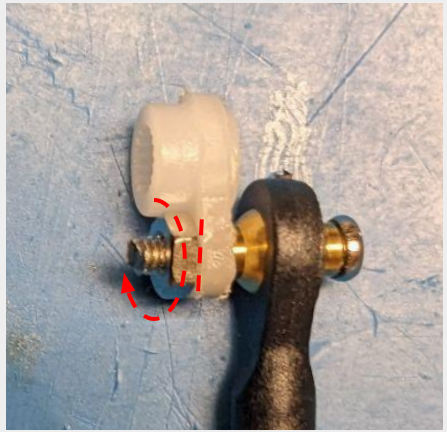
Insert spacer and start screwing second ball joint at the other end. Finish screwing them until hey come in contact with the spacer at both sides. Align both ball joint to be parallel before placing it on the toolings to check length.
If it fits without forcing and parallel way to tooling surface, it's ok. If not, adjust it by screwing or unscrewing one ball joint.
Once Length is check with tooling, screw one ball joint of 90° to make it perpendicular to the other.
You will need two of them for a whole finger assembly.

Step 2 : Finger assembly

★ **Servo horn :**

Parts needed :

- *1x* Ball joint rod assembly
- *1x* Custom servo horn
- *1x* M2x10 screw
- *1x* M2 nut



X2

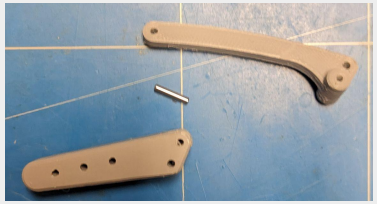
Start screw the M2 screw into the remaining hole of the custom servo horn.
As soon as it exceed the other face, put the nut on it and continue screwing horn and nut by maintaining them together.
Once ball is in contact with servo horn, finish screwing the nuts until it comes in contact to the other face of servo horn.
Don’t hesitate to force a little to well tight the link between servo horn and ball joint rod.
You will need too of them for a finger assembly.

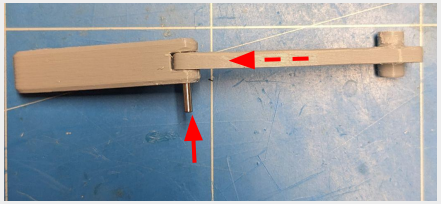
Step 2 : Finger assembly

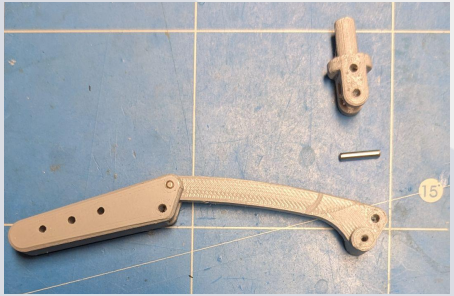
★ **Finger mechanism :**

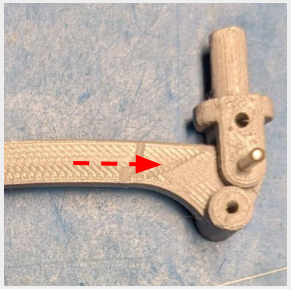
Parts needed :

- *1x* Proximal
- *1x* Distal
- *1x* Gimbal
- *1x* Link
- *2x* Axis D2x10
- *2x* Axis D2x16
- *1x* M2 Threaded rod L25mm





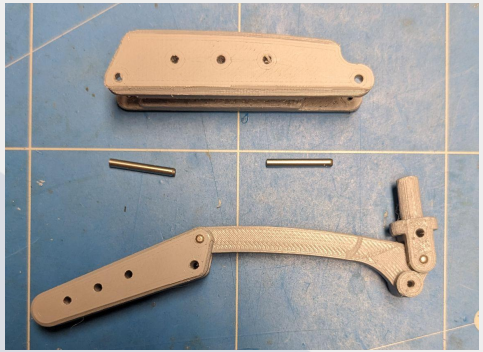




Start pushing D2x10 axis on distal part holes.
Put link part between distal part ears, and finish to push the axis until it not longer exceed from distal part.
Proceed same step with gimbal part.

Step 2 : Finger assembly

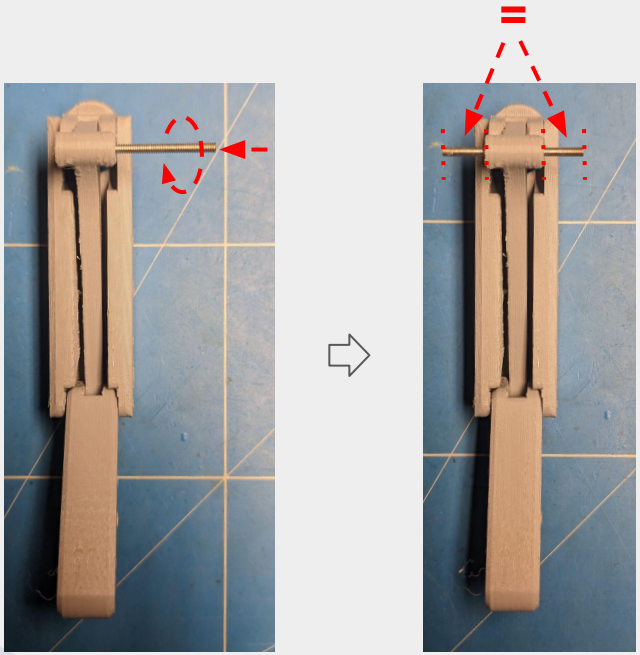
★ **Finger mechanism :**



Start pushing both D2x16 axis on proximal part holes.
Put previous sub assembly between proximal part ears, and finish to push the axis until it not longer exceed from proximal part.

Step 2 : Finger assembly

★ **Finger mechanism :**



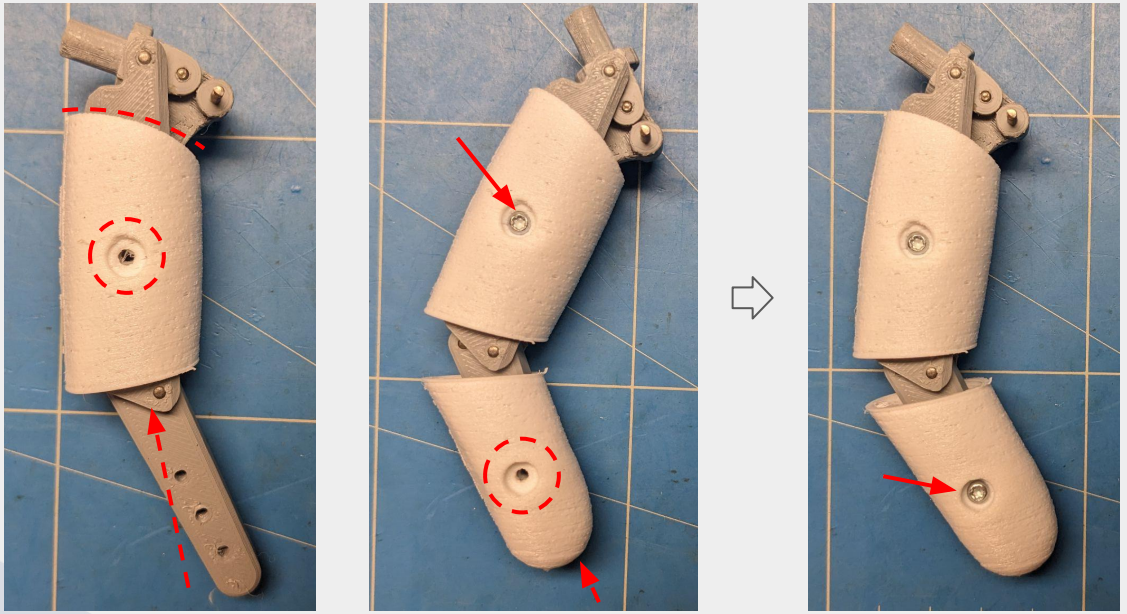
Once finger mechanism is ready, check if flexion / extension is smooth and don’t block anywhere on its whole range.
Then insert M2 threaded rod L25mm to remaining hole on the link part. (be aware to not damage thread of rod if you need to pinch it).
Screw it until both end are the same length.

Step 2 : Finger assembly

★ **Finger shells :**

Parts needed :

- *1x* Finger mechanism
- 1x Distal shell
- 1x Proximal shell
- 4x Thermoplastic screw 2.5x6



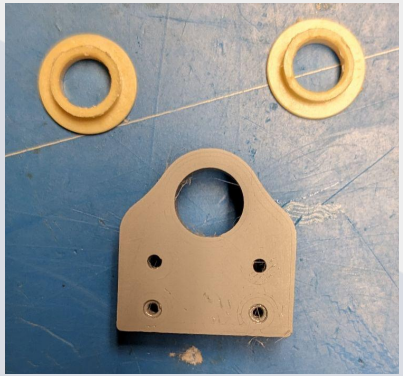
First insert proximal shell through the finger mechanism (Easier if finger is in extension pose).
Align the shell hole and the proximal part hole and screw with thermoplastic 2.5x6. Flip the finger and repeat task on opposite shell side
Insert distal shell, align both holes and screw it the same way you did for proximal shell. Flip the finger and repeat task for opposite side.

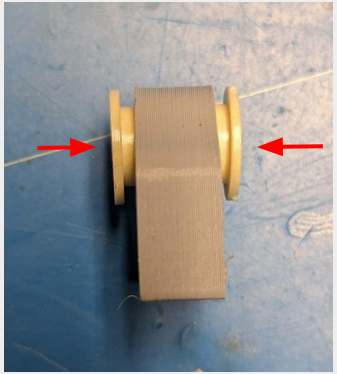
/! Don’t tight too strength the screws on shells, otherwise you may pass through the soft thin surface of shell around screws.

Step 2 : Finger assembly

★ **Bushings :**

Parts needed :
- *1x* Finger frame part1
- *2x* Bushing Dint 6mm





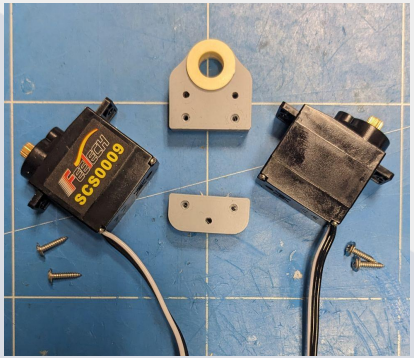
Start pushing both bushings at each side of the finger frame part1.
You will have to push against a flat surface to insert them until the end.
This will create abduction / adduction of finger

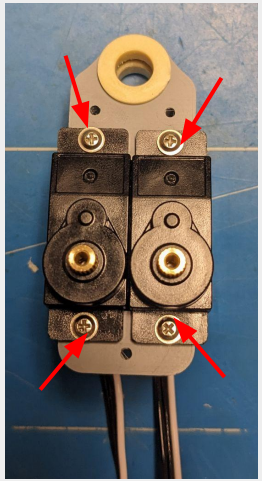
Step 2 : Finger assembly

★ **Actuators :**

Parts needed :

- *1x* Finger frame part1 with bushings
- *1x* Finger frame part2
- *2x* Feetech SCS0009
- *4x* Servo 2x7 screws





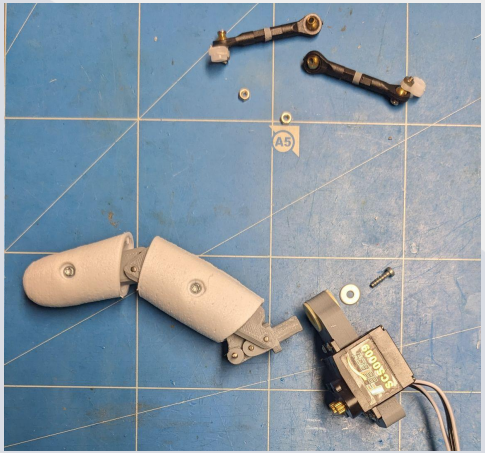
Have a detailed look on finger frame part1 & 2 : holes for screwing servos are counterbored, that will ease the screwing into plastic part.
Put both SCS0009 side by side and fix them together with finger frame part1 and part2 by using servo 2x7 screws.
Be aware to orient them as well as the servo axis is far from the abduction / adduction pivot of the finger

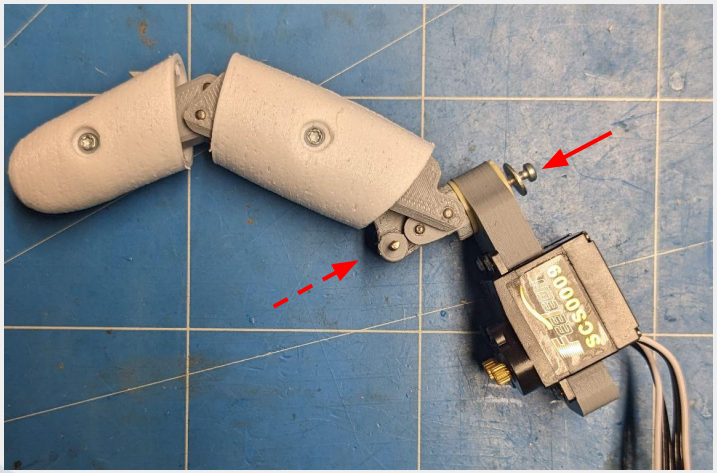
Step 2 : Finger assembly

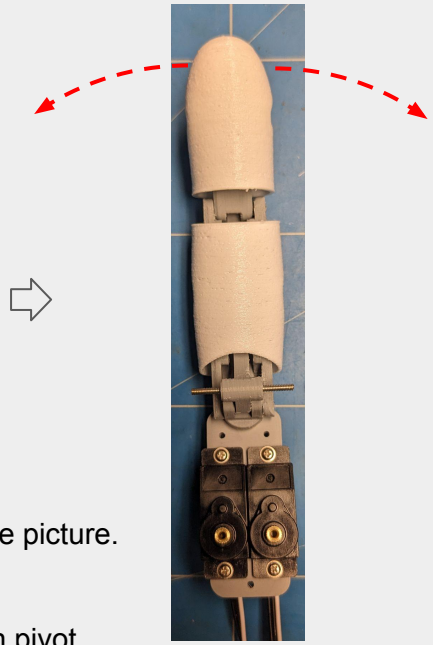
★ **Finger final assembly :**

Parts needed :

- *1x Finger mechanism*
- *1x* Actuator assembly
- *2x* Servo horn assembly
- *2x* M2 nuts
- 1x Thermoplastic screw 2.5x8
- 1x M2.5 large washer



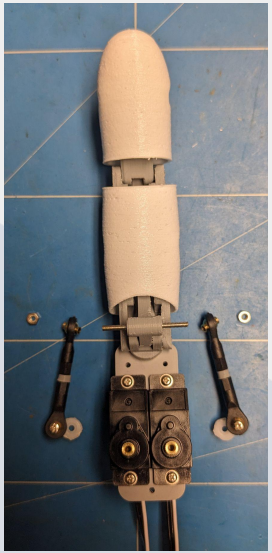


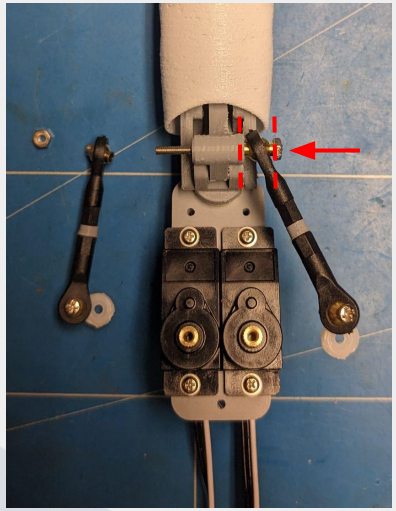


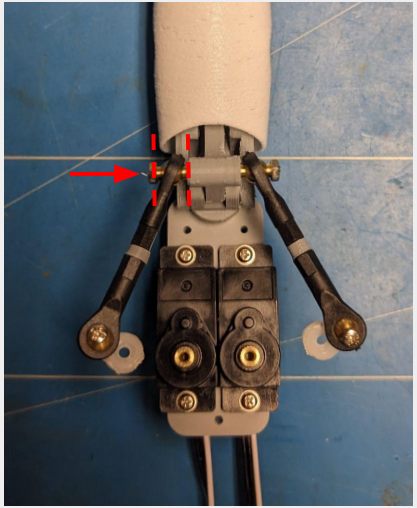
Insert finger assembly into the bushings, as shown in the above picture.
Insert the washer and the screw together into the gimbal hole.
Tight the screw until washer is in contact with the bushing.
Don’t tight it too much in order to prevent abduction / adduction pivot stuck. You can check it by manually doing abduction / adduction motion ; this should be smooth but with minimising the functional gap.

Step 2 : Finger assembly

★ **Finger final assembly :**





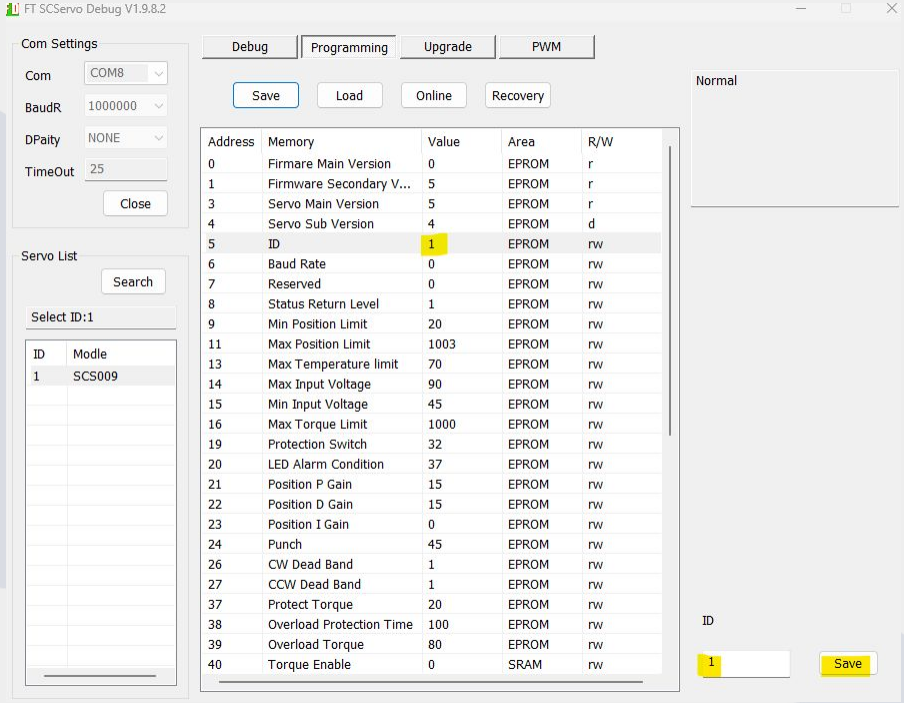


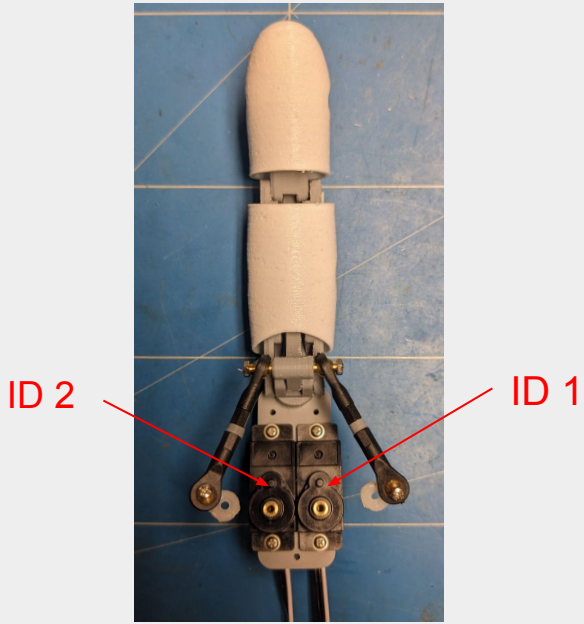
Insert the free side of a ball joint rod on the M2 threaded present on link part, by ensuring servo horn is in the good way to be later assembled on servo axis.
Screw the M2 nut on the threaded rod until ball and link are in contact. To perform good thightning, do at least half more turn on the nut.
Repeat task for other side of the threaded rod with a second ball joint rod.
If nuts seems to be not tighten enough, you can secure them with glue point (it will be bad if they leave during using)

Step 3 : Finger calibration with Python

★ **Setting IDs :**

- Plug WaveShare serial bus driver to your computer
- Run FD software (from feetech). Select corresponding Port Com and Set Baudrate to 1000000.
- Click Open then Search
- ID1 servo will pop. Change its ID as you need





Link both servos on the same serial bus using feetech serial bus link

Step 3 : Finger calibration with Python

★ **Fine tuning :**

- Run Python script “Hand_FingerMiddlePos.py”
  Be sure to change serial_port to your corresponding

```
c = Scs0009PyController(
        serial_port="COM11",
        baudrate=1000000,
        timeout=0.5,
    )
```

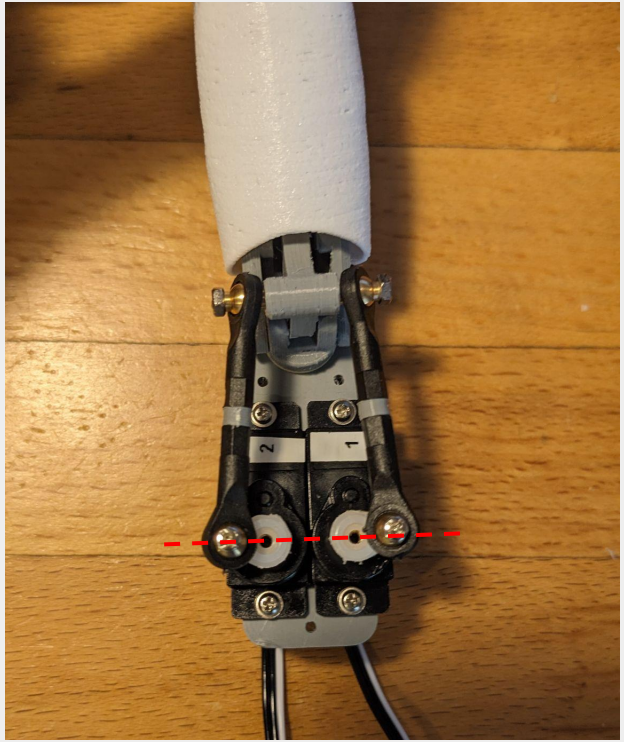
By default, middle position is set to 0
This program will servos in their middle position

```
ID_1 = 1 #Change to servo ID you want to calibrate
ID_2 = 2 #Change to servo ID you want to calibrate
MiddlePos_1 = 0 #Middle position for servo ID_1
MiddlePos_2 = 0 #Middle position for servo ID_2
```

```
def ServosInMiddle ():

    c.write_goal_speed(ID_1, 6) # Set speed for ID_1 to 6 => Max Speed
    c.write_goal_speed(ID_2, 6) # Set speed for ID_1 to 6 => Max Speed
    Pos_1 = np.deg2rad(MiddlePos_1)
    Pos_2 = np.deg2rad(MiddlePos_2)
    c.write_goal_position(ID_1, Pos_1)
    c.write_goal_position(ID_2, Pos_2)
    time.sleep(0.01)
```

- Place servo horns as following picture (= middle position), as closed as you can
- Screw both servo horns with M2x4 screw



Each servo has a different 0 position regarding coupling with servo horn…, we will need to fine tune middle position in next step

Step 3 : Finger calibration with Python

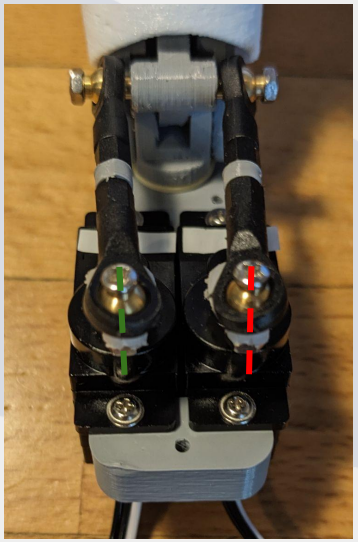
★ **Fine tuning :**

- Run Python script “Hand_FingerTest.py”

  Be sure to change serial_port to your corresponding

```
c = Scs0009PyController(
        serial_port="COM11",
        baudrate=1000000,
        timeout=0.5,
    )
```

Stop the program as soon as the finger is in closed position, and check if servo horns are correctly align with middle plan of the servo. If not, change the middle position a little bit to fit with this requirement (servo horns aligned with middle servo middle plan when finger is closed). Value is an angle value in °.



In this example :
- right servo horn (ID1) is a bit not far enough
 => New Middle pos should be increased of +3°

- left servo horn (ID2) is OK

(Due to symmetrical location of servos, rotation way is not obvious, perform several settings to be sure of the good fine tuned middle pos)

```
ID_1 = 1 #Change to servo ID you
ID_2 = 2 #Change to servo ID you
MiddlePos_1 = 3 #Middle position
MiddlePos_2 = 0 #Middle position
```

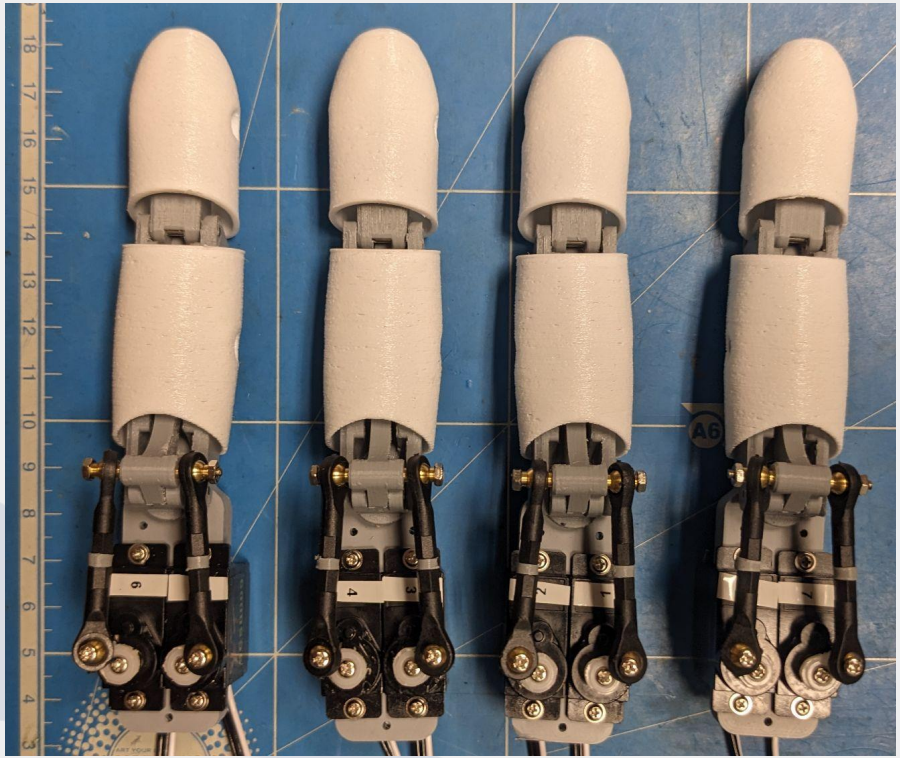
Save those values somewhere you can easily retrieve it later !

Step 3 : Finger calibration with Python

★ **Fine tuning :**

For the 4 fingers you build, you will have to set different middle position by performing calibration as previously. Just keep in mind that each servos has to be with unique ID.
ID are defined as follow :

-Index finger : 1 & 2
-Middle finger : 3 & 4
-Ring finger : 5 & 6
-Thumb finger : 7 & 8



Fine tuned middle poses

1 -> 3
2 -> 0
3 -> -5
4 -> -8
5 -> 2
6 -> 5
7 -> -12
8 -> 0

You can easily changed servo ID you are calibrating in finger test program.

```
ID_1 = 3 #Change to servo ID you want to calibrate
ID_2 = 4 #Change to servo ID you want to calibrate
MiddlePos_1 = -5 #Middle position for servo ID_1
MiddlePos_2 = -8 #Middle position for servo ID_2
```

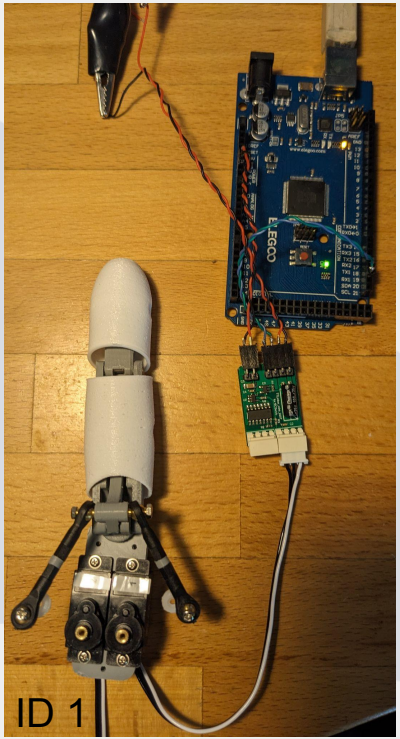
```
ID_1 = 5 #Change to servo ID you want to calibrate
ID_2 = 6 #Change to servo ID you want to calibrate
MiddlePos_1 = 2 #Middle position for servo ID_1
MiddlePos_2 = 5 #Middle position for servo ID_2
```

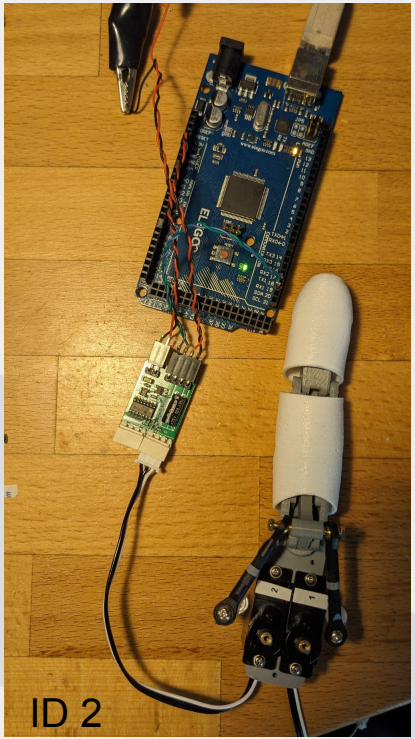
```
ID_1 = 7 #Change to servo ID you want to calibrate
ID_2 = 8 #Change to servo ID you want to calibrate
MiddlePos_1 = -12 #Middle position for servo ID_1
MiddlePos_2 = -0 #Middle position for servo ID_2
```

Step 3 : Finger calibration with Arduino

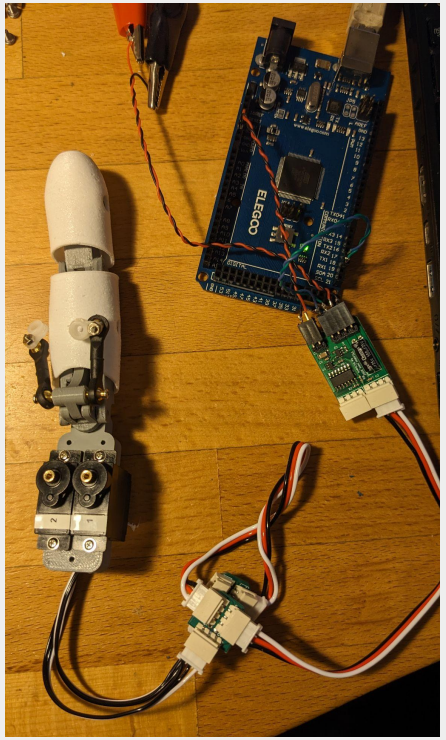
★ **Setting IDs :**

- Follow this tutorial to set servos ID :
  https://www.robot-maker.com/forum/topic/14804-presentation-et-fonctionnement-des-servomoteurs-feetech/





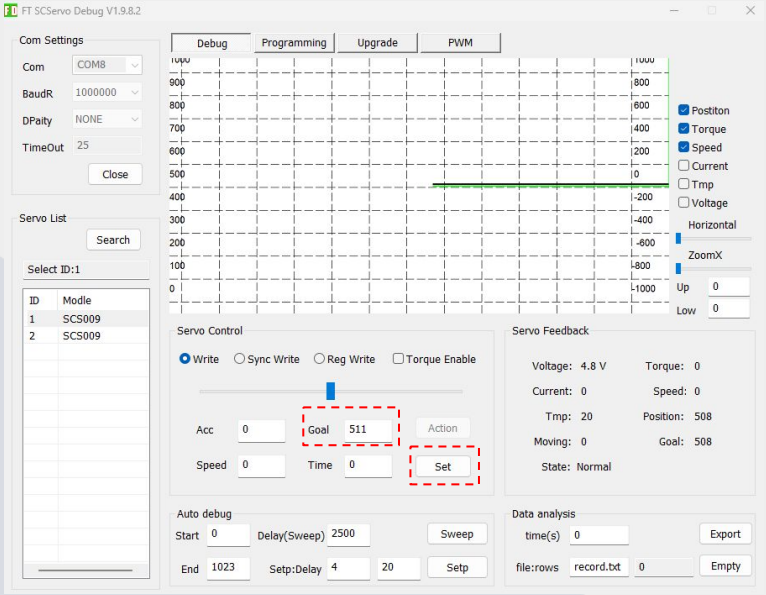
Link both servos on the same serial bus using feetech serial bus link and reconnect it to the arduino, in driving configuration. (refer to tutorial)



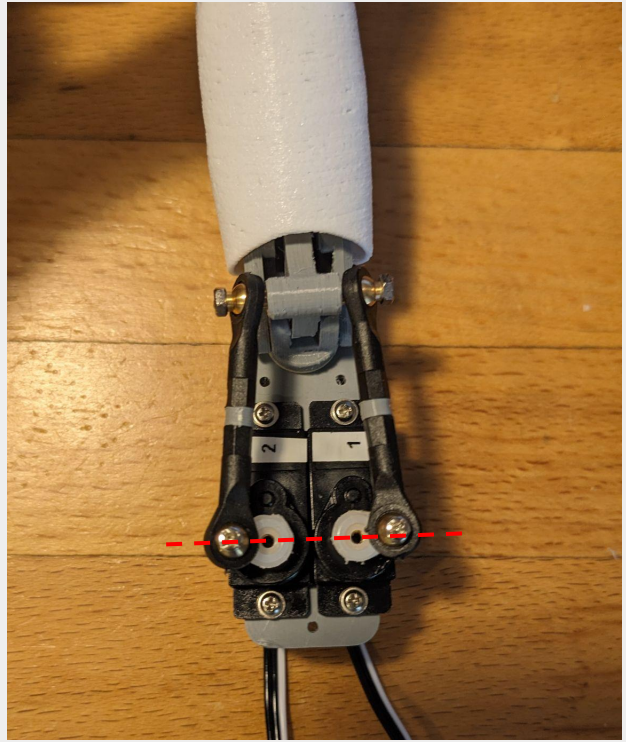
Step 3 : Finger calibration with Arduino

★ **Fine tuning :**

- Set position 511 for each Servo with Feetech software



- Place servo horns as following picture (= middle position), as closed as you can
- Screw both servo horns with M2x4 screw



Each servo has a different 500 position regarding coupling with servo horn…, we will need to fine tune middle position in next step

Step 3 : Finger calibration with Arduino

★ **Fine tuning :**

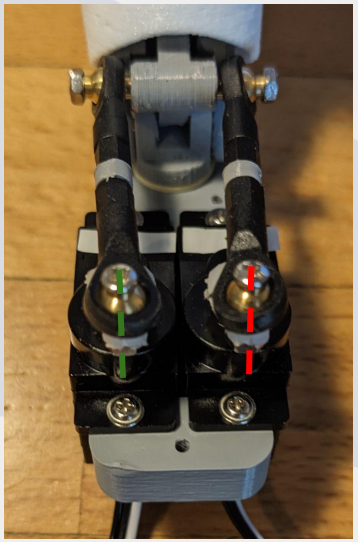
- Run Arduino program “4-Fingers Hand_FingerTest.ino”

  By default, middle position is set to 511

  This program will open and closed the finger, and then do abduction/adduction movement

```
// Finger parameters
int ID_1 = 1; //Change to servo ID you want
int ID_2 = 2; //Change to servo ID you want
int MiddlePos_1 = 511;  // Middle position
int MiddlePos_2 = 511;  // Middle position
```

- Stop the program as soon as the finger is in closed position, and check if servo horns are correctly align with middle plan of the servo. If not, change the middle position a little bit to fit with this requirement (servo horns aligned with middle servo middle plan when finger is closed). Value is a raw value, so 1 step=0.293°.



In this example :

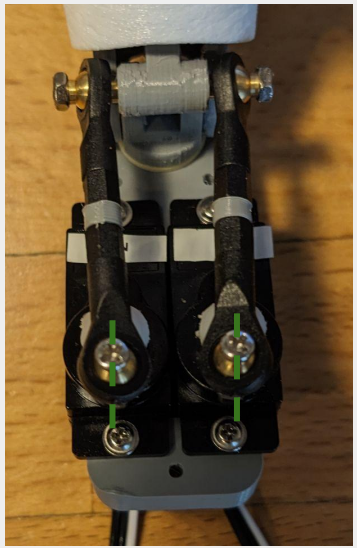
- right servo horn (ID1) is a bit not far enough

  => New Middle pos should be increased to 520

- left servo horn (ID2) is OK with 511 value

(Due to symmetrical location of servos, rotation way is not obvious, perform several settings to be sure of the good fine tuned middle pos)

```
// Finger parameters
int ID_1 = 1; //Change to servo ID you want
int ID_2 = 2; //Change to servo ID you want
int MiddlePos_1 = 520;  // Middle position
int MiddlePos_2 = 511;  // Middle position
```



Save those values somewhere you can easily retrieve it later !

Step 3 : Finger calibration with Arduino

★ **Fine tuning :**

For the 4 fingers you build, you will have to set different middle position by performing calibration as previously. Just keep in mind that each servos has to be with unique ID.
ID are defined as follow :

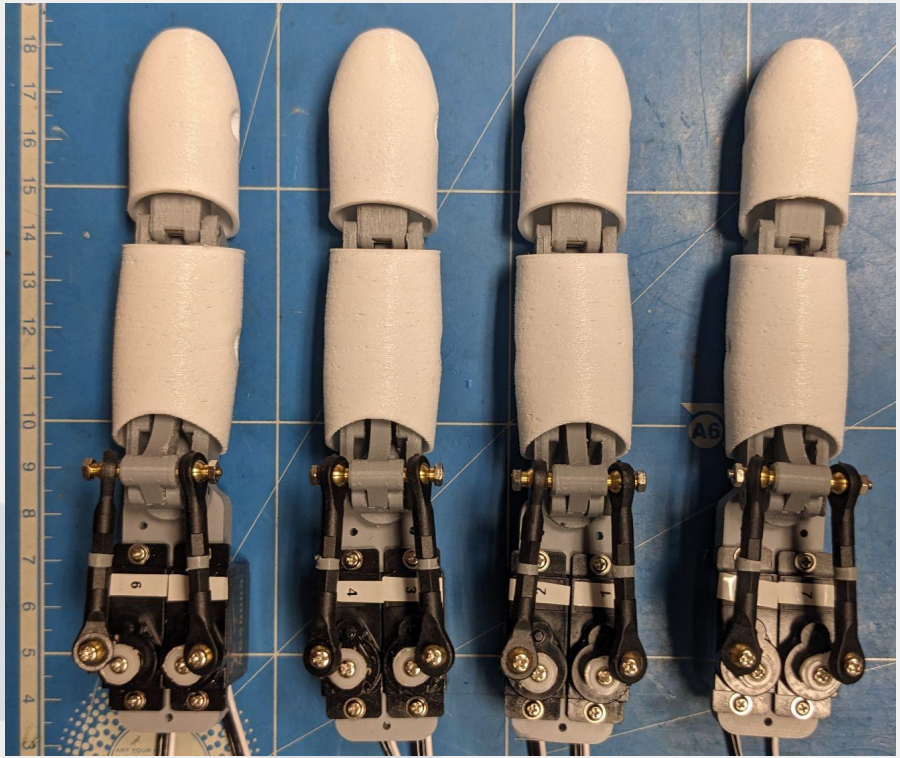
-Index finger : 1 & 2
-Middle finger : 3 & 4
-Ring finger : 5 & 6
-Thumb finger : 7 & 8

You can easily changed servo ID you are calibrating in finger test program.

```
// Finger parameters
int ID_1 = 3; //Change to servo ID you want to calibrate
int ID_2 = 4; //Change to servo ID you want to calibrate
int MiddlePos_1 = 500;  // Middle position for servo ID_1
int MiddlePos_2 = 490;  // Middle position for servo ID_2
```

```
// Finger parameters
int ID_1 = 5; //Change to servo ID you want to calibrate
int ID_2 = 6; //Change to servo ID you want to calibrate
int MiddlePos_1 = 515;  // Middle position for servo ID_1
int MiddlePos_2 = 520;  // Middle position for servo ID_2
```

```
// Finger parameters
int ID_1 = 7; //Change to servo ID you want to calibrate
int ID_2 = 8; //Change to servo ID you want to calibrate
int MiddlePos_1 = 480;  // Middle position for servo ID_1
int MiddlePos_2 = 511;  // Middle position for servo ID_2
```



Fine tuned middle poses

1	->	520
2	->	511
3	->	500
4	->	490
5	->	515
6	->	520
7	->	480
8	->	511

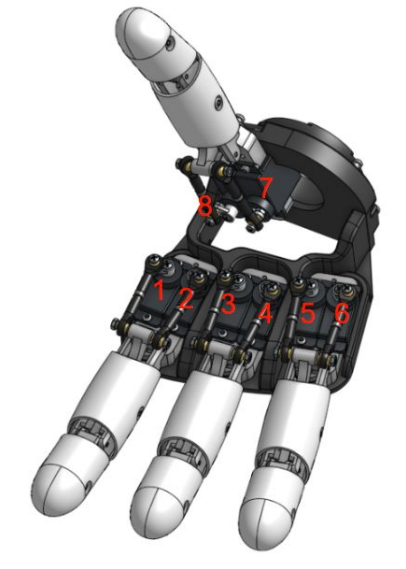
Step 4 : Hand assembly

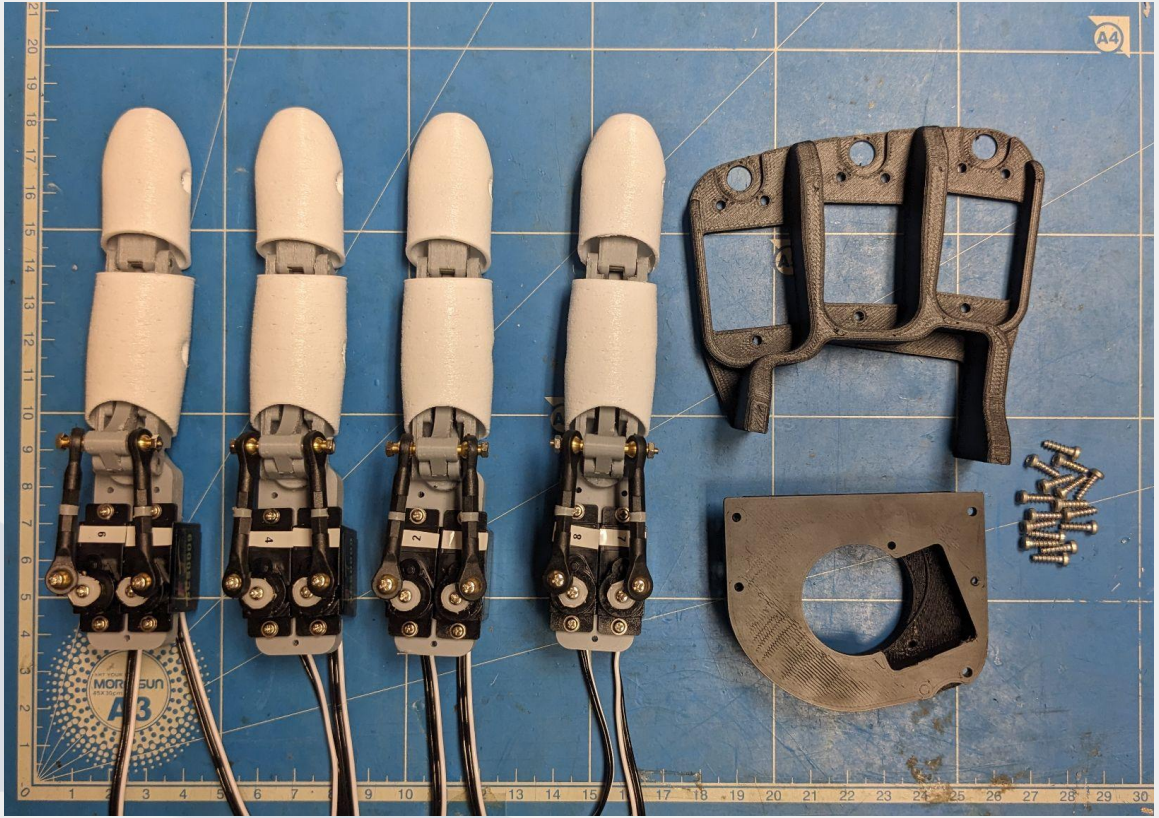
★ Fingers mounting :

Parts needed :

- *4x* Fingers calibrated
- *1x* Hand plate
- *1x* Wrist interface
- *16x* Thermoplastic screws 2.5x8

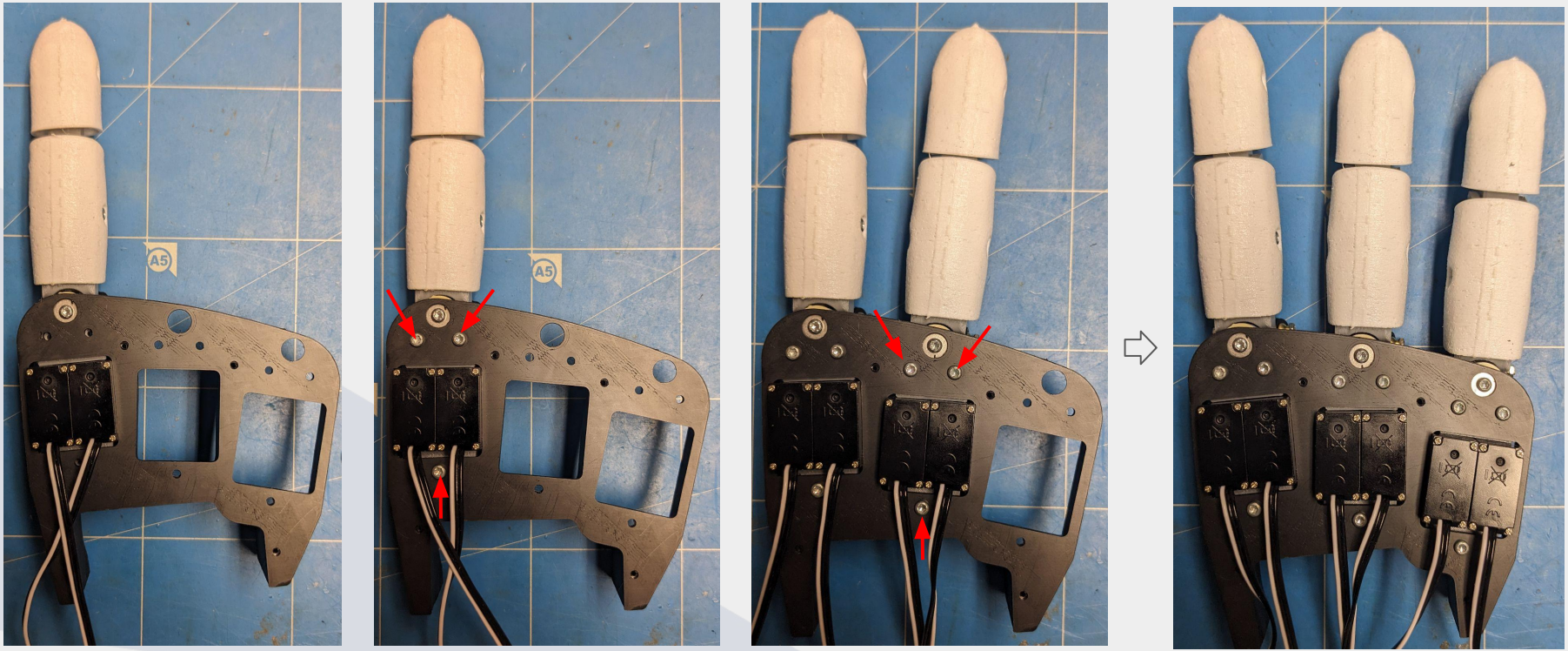
/!\ reminder about IDs related to finger location





Step 4 : Hand assembly

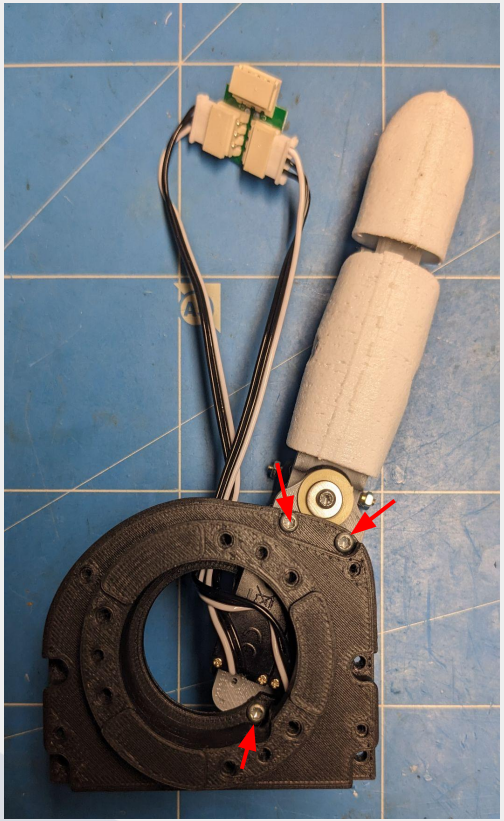
★ **Fingers mounting :**



Put Index finger on the left location (regarding top view), by passing wires through the rectangular hole before.
Fix the finger with 3x thermoplastic screws 2.5x8.
Repeat operation for middle finger in the middle location, and finally ring finger on the right location (regarding top view).

Step 4 : Hand assembly

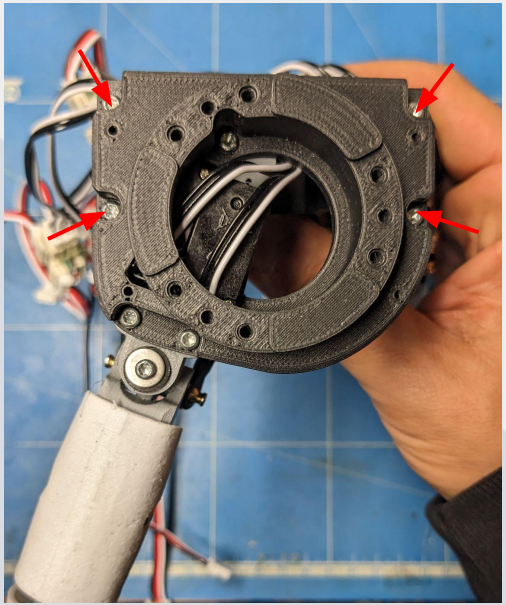
★ **Thumb mounting :**

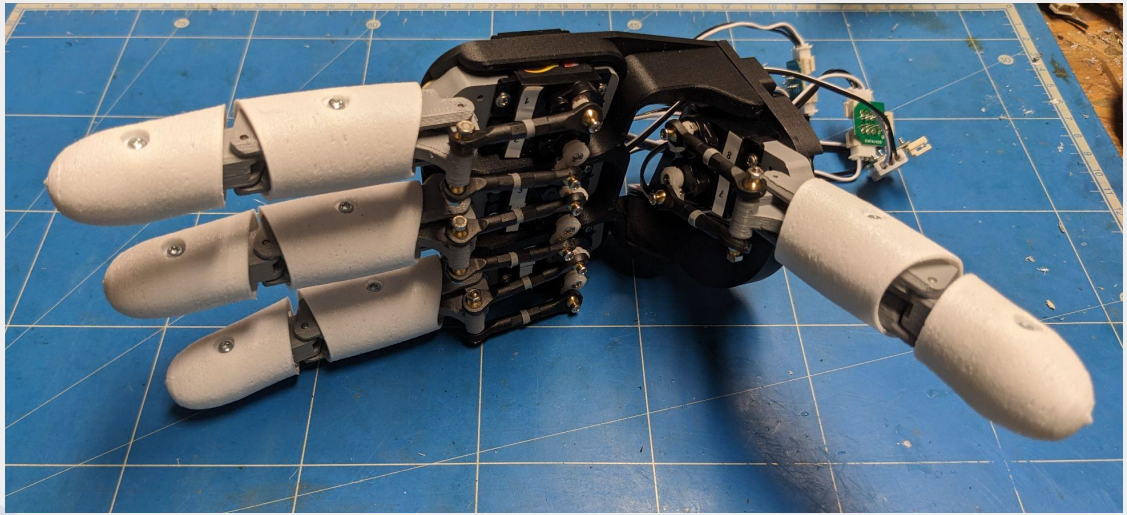


Put the thumb finger on the location in wrist interface part. Be careful to not pinch servo wires while fixing it with 3x thermoplastic screws 2.5x8. Let the wires going on the inside (finger side).

Step 4 : Hand assembly

★ **Hand assembly:**





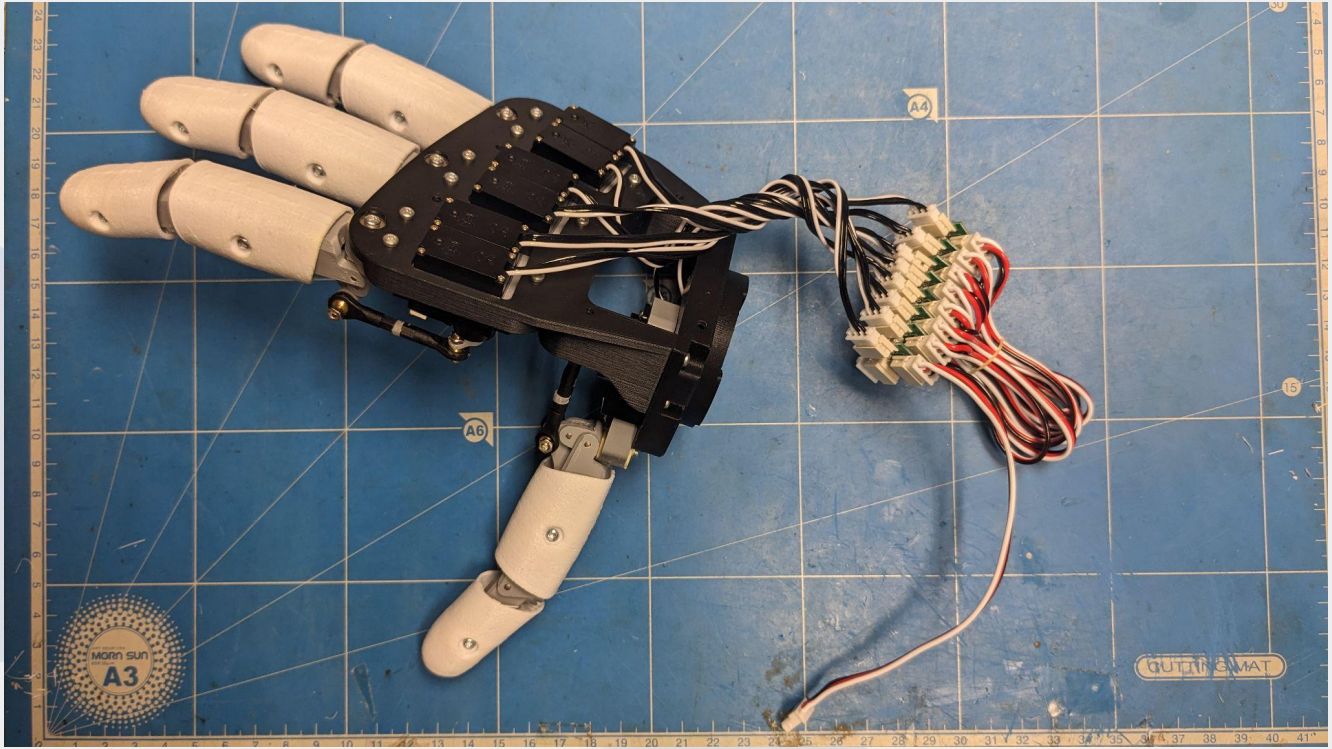
Pass the thumb wires through the hand plate remaining aperture, and put Wrist interface and Hand plate together, by fixing them with 4x thermoplastic screws 2.5x8.

Step 4 : Hand assembly

★ **Hand assembly :**

-

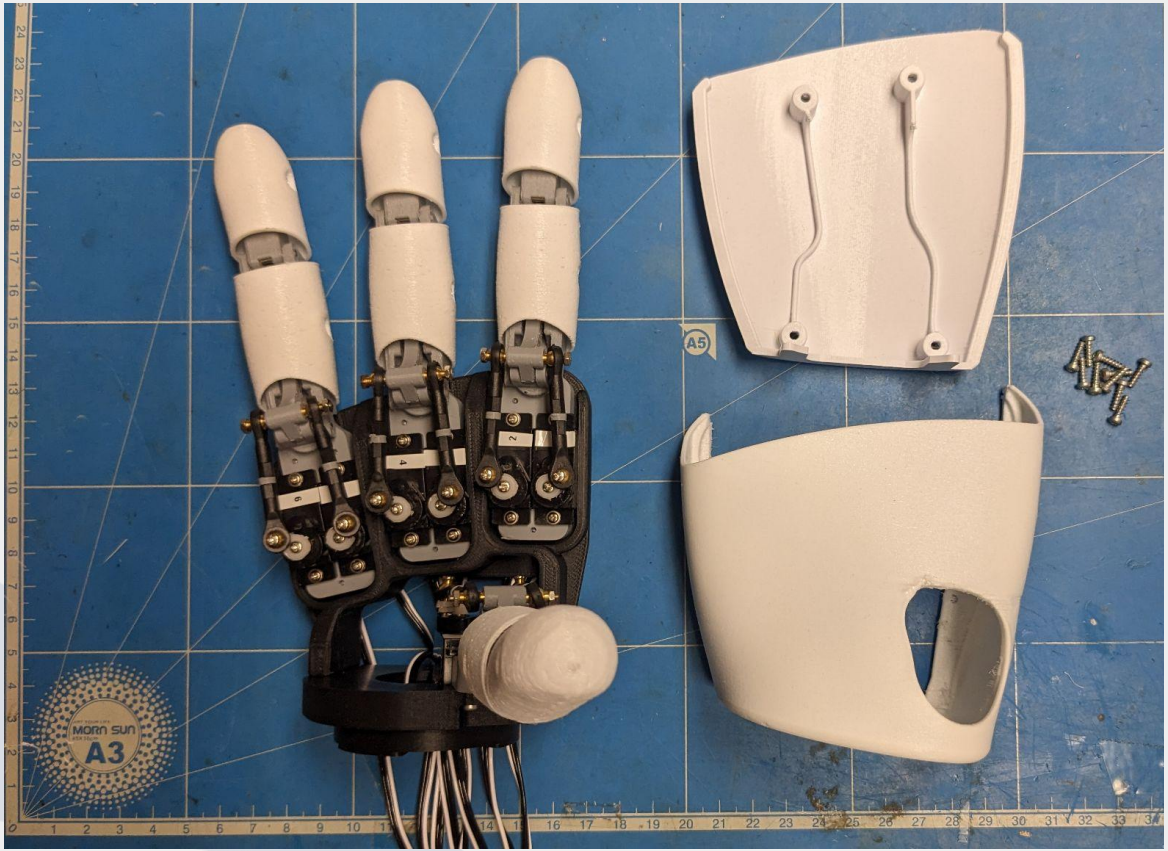
Link all servos on the same bus



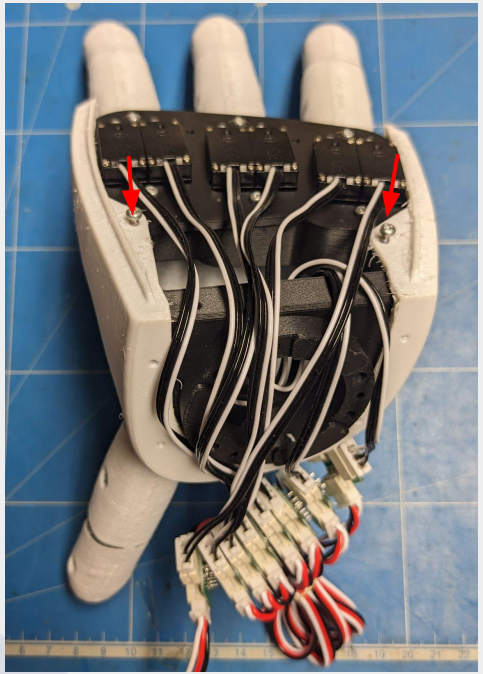
Step 5: Shells assembly

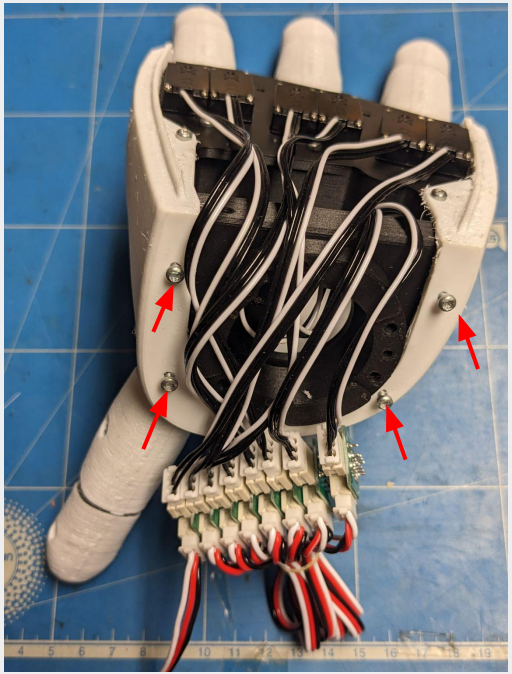
Parts needed :

- *1x* Hand with all fingers calibrated
- *1x* Palm shell (soft)
- *1x* Top Shell
- *10x* Thermoplastic screws 2.5x8



Step 5: Shells assembly



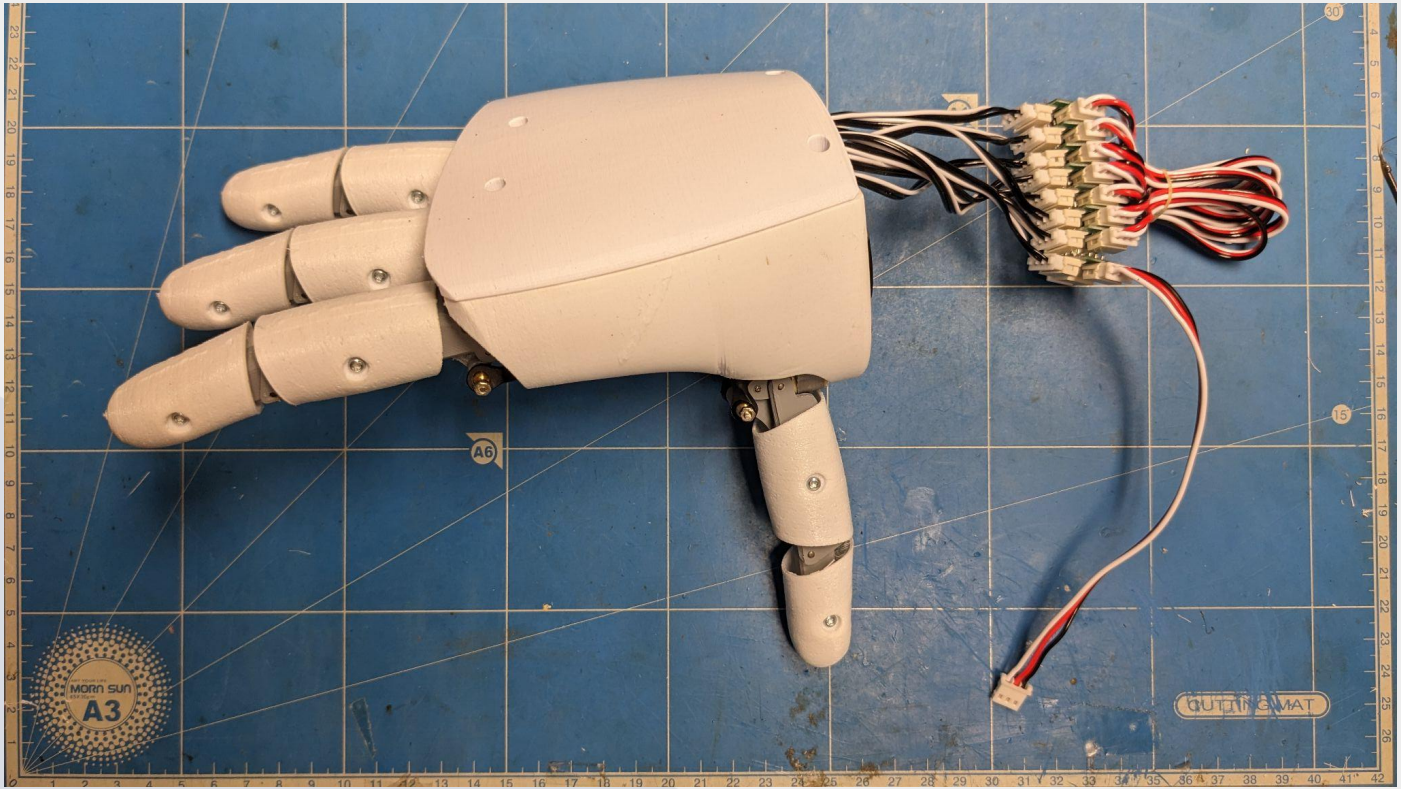


Insert palm shell through the thumb aperture, and pass the shell ears on the top surface of the hand plate.
Screw palm shell with first 2 thermoplastic screws on the hand plate.
Finish screwing the palm shell with 4x thermoplastic on the wrist interface part

Step 5: Shells assembly

Put top shell on the top of the hand, in order to close the hand. Be aware to pass the cables at the aperture of the top shell and check if jonction between palm shell and top shell is fine. Screw it with 4 last thermoplastic screws 2.5x8.

Step 5: Enjoy



You did it, congratulations !