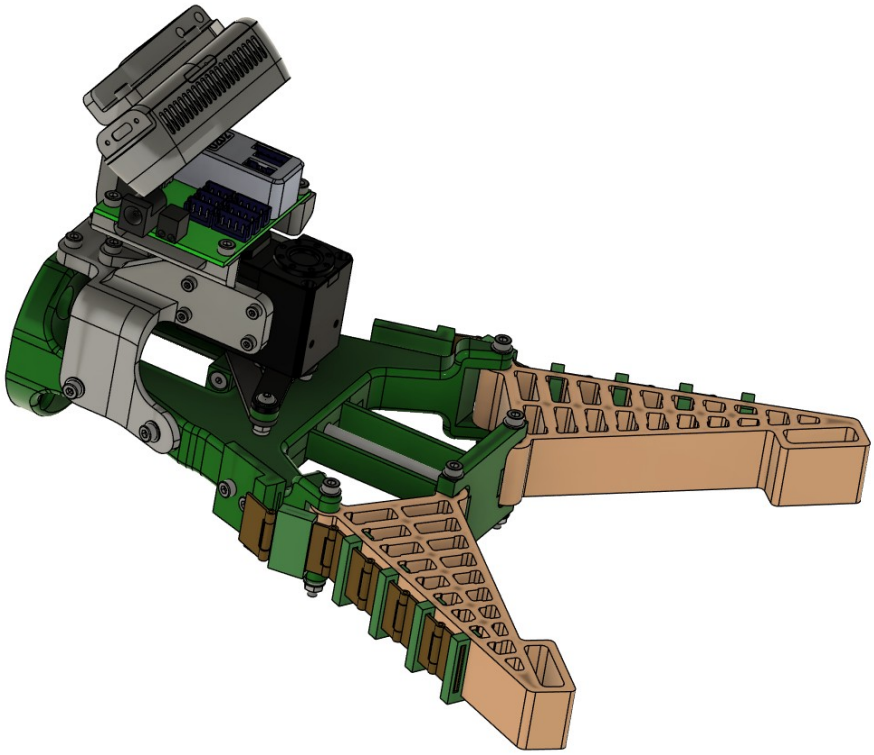
SofIA

Version 1.0



Assembly Instructions

Date: May 22, 2025

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1. Bill of Materials

All parts required for assembly are listed below with the name, quantity, material, manufacturing method or vendor, and description.

Part name	Quantity	Material	Manufacturing method/Vendor	Description
Body	1	PETG	In-house manufacturing using FFF 3D printing	Gripper's body. Before using insert 14 M3 threaded inserts!
Linear ball bearing 4x8x12	2	-	TULI (or similar)	Two linear ball bearings for the linear guide
Linear guide 4 mm	1	C45	TULI (or similar) + in-house cutting	Length is 89 mm
Slider cap	1	PETG	In-house manufacturing using FFF 3D printing	Bolted to slider base, holds one end of the linear guide
Slider base	1	PETG	In-house manufacturing using FFF 3D printing	Serve as a connecting point to the mechanism. Before using insert 5 M3 threaded inserts!
Guide plate	1	PETG	In-house manufacturing using FFF 3D printing	Transfer motion to fingers. Before using insert 2 M3 threaded inserts!
Side plate left	1	PETG	In-house manufacturing using FFF 3D printing	-
Side plate right	1	PETG	In-house manufacturing using FFF 3D printing	-

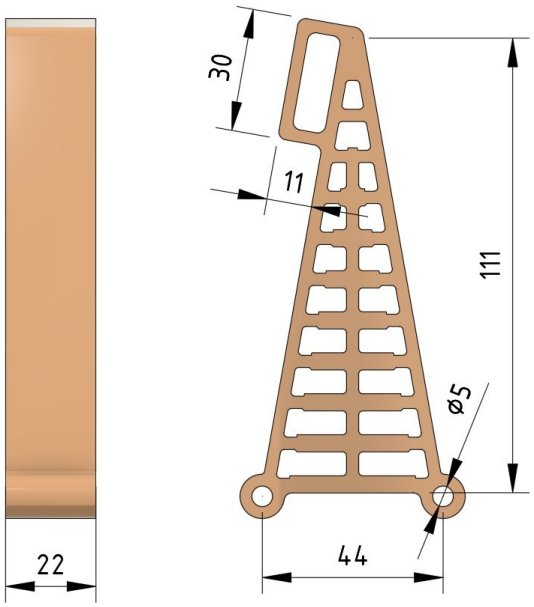
Body cover	1	PETG	In-house manufacturing using FFF 3D printing	Keeps in place linear ball bearings.
Dynamixel XM-430	1	-	Robotis (or similar)	Servomotor
Crank	1	CFRP	CNC laser/water cutting	Connects to motor. The first part of the slider crank mechanism.
Distance ring	1	PETG	In-house manufacturing using FFF 3D printing	Keeps distance between the crank and the connecting rod.
Connecting rod	1	CFRP	CNC laser/water cutting	
Motor adapter	1	PETG	In-house manufacturing using FFF 3D printing	Holds motor in place. Before using insert 3 M3 threaded inserts!
U2D2 carrier	1	PETG	In-house manufacturing using FFF 3D printing	Carries U2D2 Power Hub. Before using insert 4 M3 threaded inserts!
U2D2 Power Hub	1	-	Generation robots (or similar)	Needed to provide power and communication to Dynamixel motor
Camera carrier	1	PETG	In-house manufacturing using FFF 3D printing	Heightens the camera above the gripper. Before using insert 2 M3 threaded inserts!
Camera connector	1	PETG	In-house manufacturing using FFF 3D printing	Connects camera to carrier
Intel RealSense D435	1	-	Intel (or similar)	Gives information about perception.
Chain mount	2	PETG	In-house manufacturing using FFF 3D printing	Connects serial chain hinge support to gripper’s body

Hook	10-14	PETG	In-house manufacturing using FFF 3D printing	Ring-like connector or clip for attaching serial chain to the finger. Its number depends on your specific application
Door hinges	12-16	Steel	Local hardware shop (or similar)	30x19 mm.
Finger 100	2	Urethane rubber Vytaflex 30	In-house manufacturing process.	Follow section 2 for detailed description on the finger manufacturing.
Countersunk Hexagon Screw	6	Steel (Zn)	M3x8, DIN 7991	-
Head Cap Hexagon Screw	4+1+19	Steel (Zn)	M3x8, DIN 912	-
Washer 3.2	15	Steel (Zn)	M3, DIN 125	-
Hexagon Locknut	1	Steel (Zn)	M3, DIN 985	-
Hexagon Socket Button Head Screw	1	Steel (Zn)	M3x12, DIN ISO 7380	-
Head Cap Hexagon Screw	8+8	Steel (Zn)	M2.5x8, DIN 912	-
Hexagon Nut	4	Steel (Zn)	M3, DIN 934	-
Head Cap Hexagon Screw	4	Steel (Zn)	M3x40, DIN 912	-
Threaded insert M3	5+2+14+3+4+2	Brass	CNC Kitchen (or similar)	-

2. Finger Design and Manufacturing

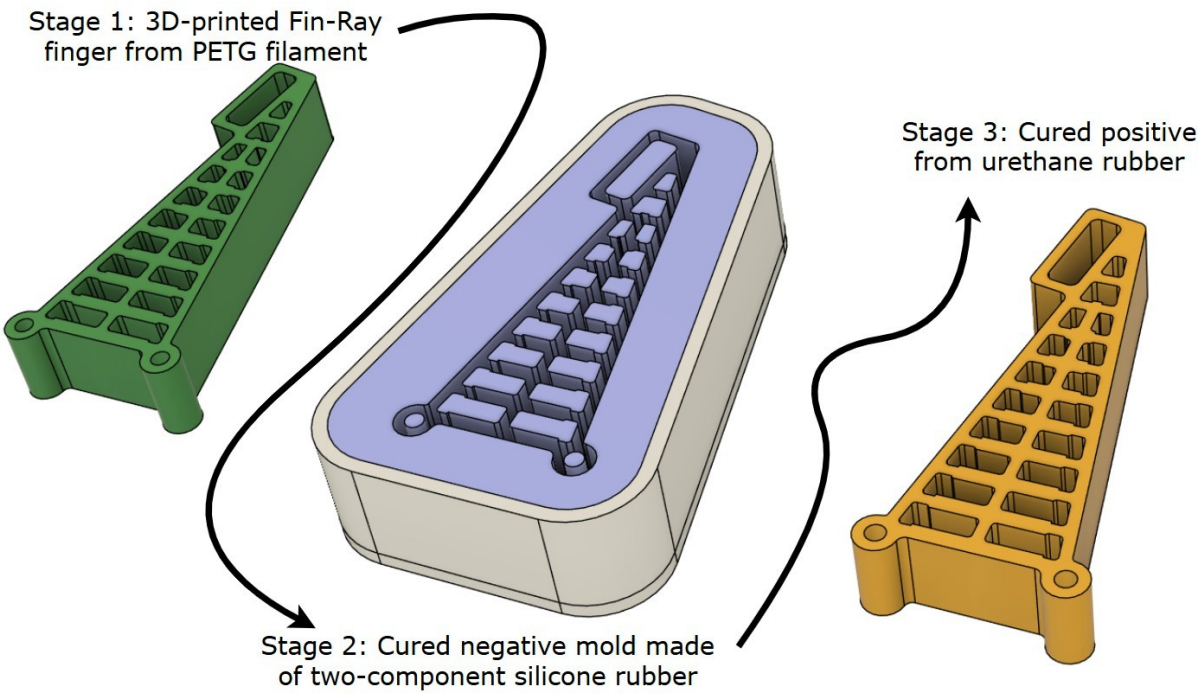
2.1. Brief summary of Fin-Ray finger design

The Fin-Ray finger geometry used in SofIA was selected heuristically, based on proportional reasoning and hands-on experience, rather than through formal optimization methods. This approach ensured a functional and adaptable design suitable for compliant grasping. The 3D model is available as a `.stp` file within the SofIA gripper CAD package.



2.2. Three stage fabrication:

The fabrication of the soft Fin-Ray fingers is carried out in three stages: 3D printing the positive mold, casting a silicone negative mold, and finally casting the finger using urethane rubber.



Stage 1: 3D Print Positive Mold

- Use PETG filament to 3D print the positive mold based on the provided `.stp` geometry.
- Ensure that M3 mounting holes are included and correctly dimensioned in the print.

Stage 2: Silicone Mold Casting

- Mix **Extrasil RTV-2** silicone elastomer at a 100:3 ratio (base to catalyst), following the manufacturer's instructions.
- Pour the mixture over the 3D-printed mold (not included in the final part).
- Allow the silicone to cure for approximately 4 hours at 25°C in a dust-free environment.

Stage 3: Urethane Rubber Casting

- Once the silicone mold has cured, remove the positive mold carefully.
- Mix **VytaFlex 30** urethane rubber at a 1:1 ratio.
- Slowly pour the mixture into the silicone mold to avoid air bubbles.
- Leave the cast to cure for at least 16 hours at room temperature.

Step 4: Finalizing the Finger

- Carefully demold the urethane rubber finger.
- Trim any flashing or excess material with scissors or a scalpel.
- Ensure all M3 mounting holes are fully open and ready for assembly.

3. Actuator and Mechanism Assembly

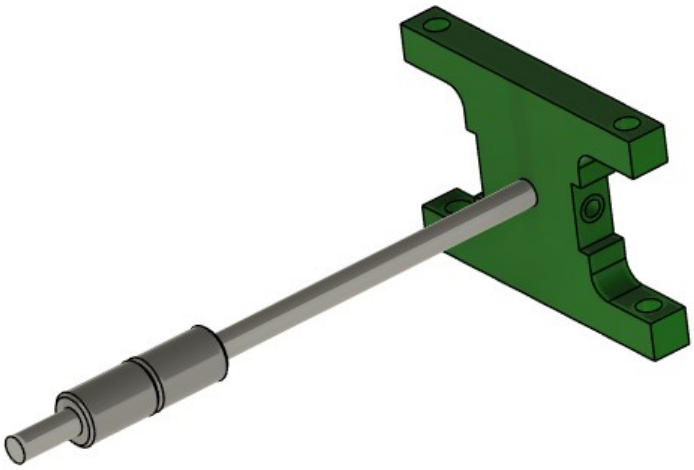
Before you begin:

Make sure that all required parts have M3 threaded inserts properly installed.

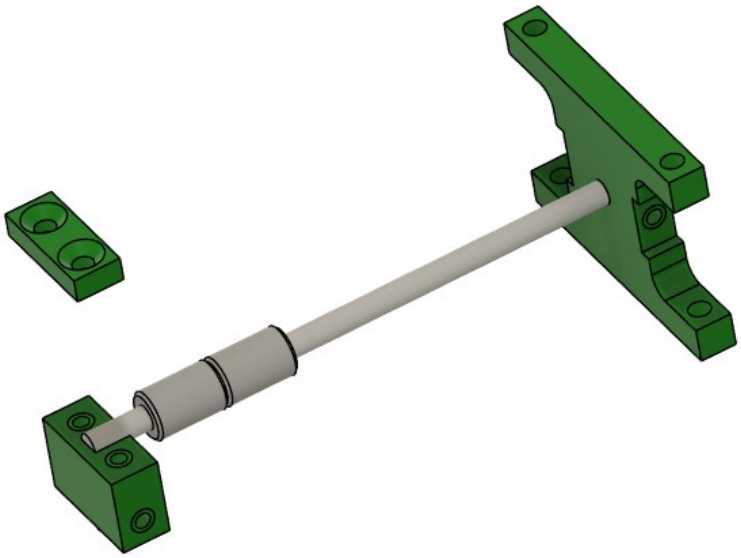
Install the linear guide assembly

1. **Fix the 4 mm linear guide into the bearings.** Ensure the bearings are positioned correctly and not sliding along the guide at this stage.

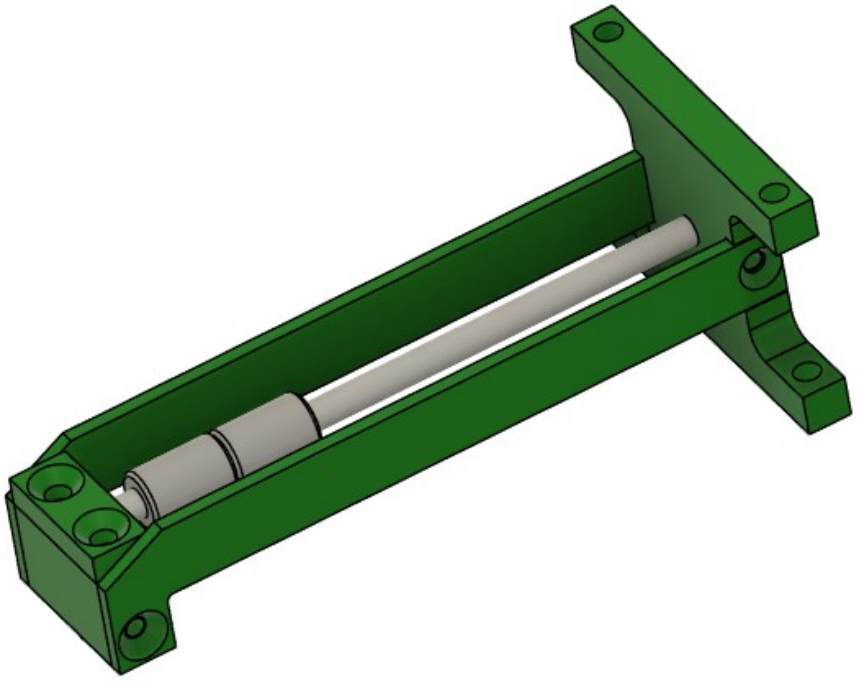
2. **Attach the guide plate.** Press-fit the guide plate onto one end of the linear rail to secure the bearings in place.



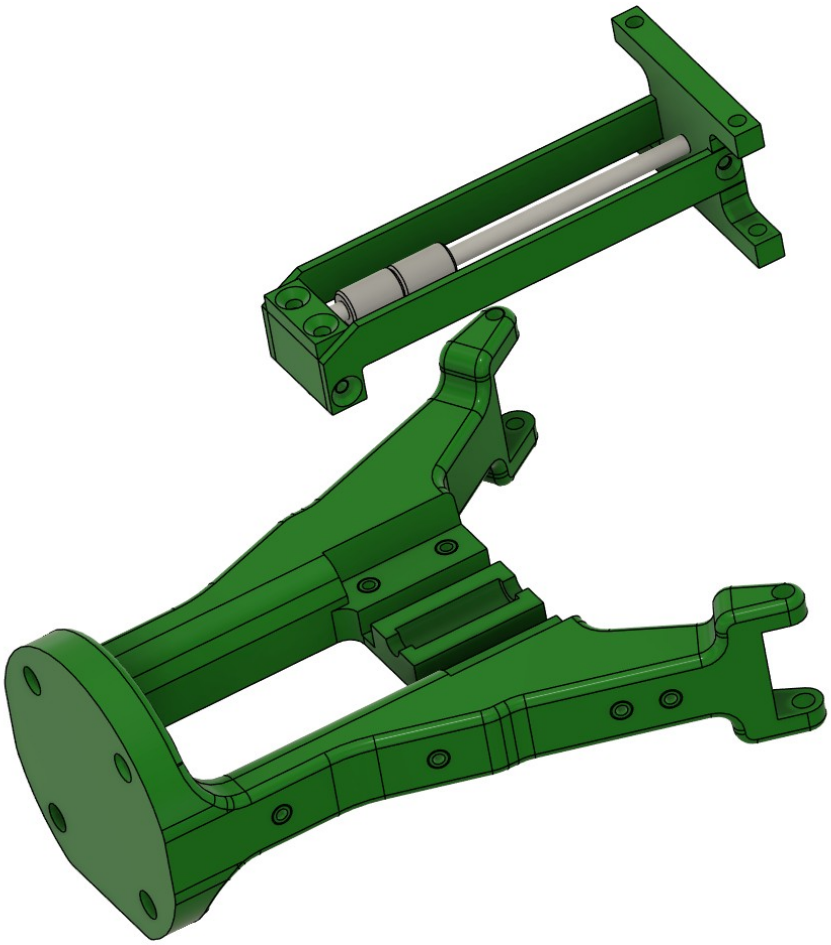
3. **Install the slider base.**
   Slide the base onto the opposite end of the rail. Use the slider cap to fasten the slider base and guide rail together securely.



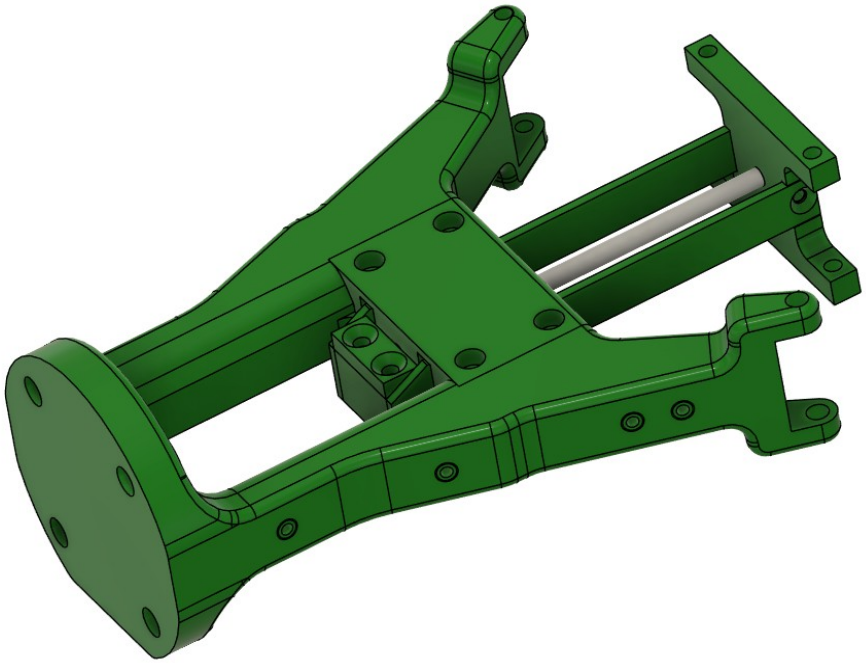
4. **Attach side plates.**
   Use the left and right side plates to connect the slider base to the guide plate. Pay attention to the correct orientation during assembly.



5. **Insert the subassembly into the body.**
   Place the completed subassembly into the designated slot in the gripper body. The bearings should fit snugly.



6. **Install the body cover.**
   Place the body cover over the assembly and fasten it using M3 screws.



7. **Check movement.**
   Manually move the slider up and down to test for smooth motion. There should be no resistance—motion should feel fluid and guided.

Mount the mechanism

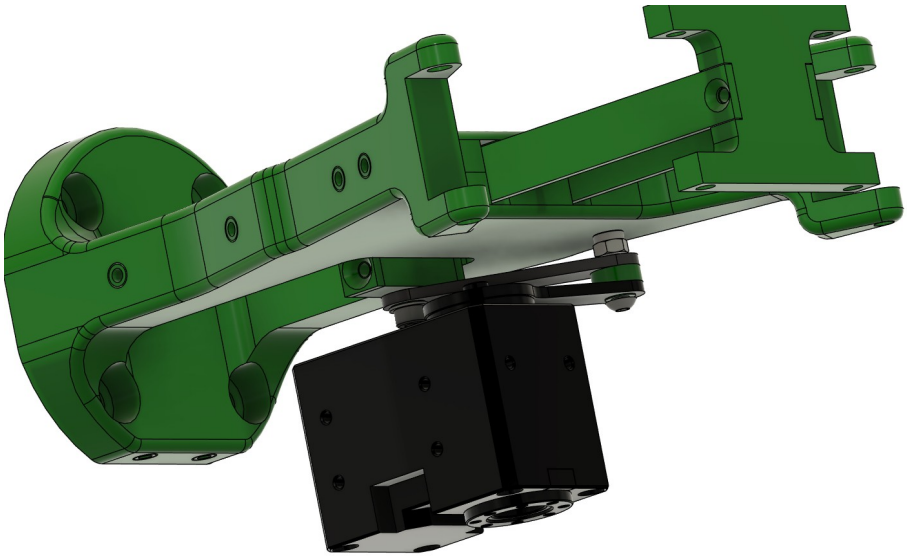
1. **Attach the crank to the motor.**
   Use M2.5 screws to fasten the crank to the motor shaft. Ensure the motor horn is securely mounted and properly aligned.

2. **Install the distance ring.**
   Place the distance ring on the free end of the crank.

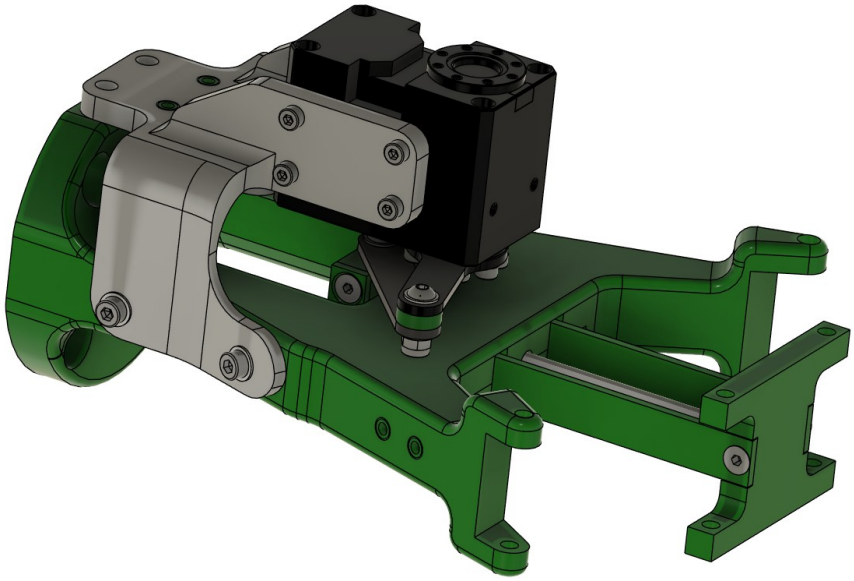
3. **Mount the connecting rod.**
   Position the connecting rod on top of the distance ring and secure it with an

M3 screw and locknut. Don’t forget to include washers. Ensure the joint remains rotational—do not overtighten.

4. **Connect to the slider base.**
Attach the other end of the connecting rod to the slider base using an M3 screw.



5. **Connect the motor to the motor adapter.**
Attach the sides of the motor adapter to the sides of the motor. Also, attach the motor adapter to the body.

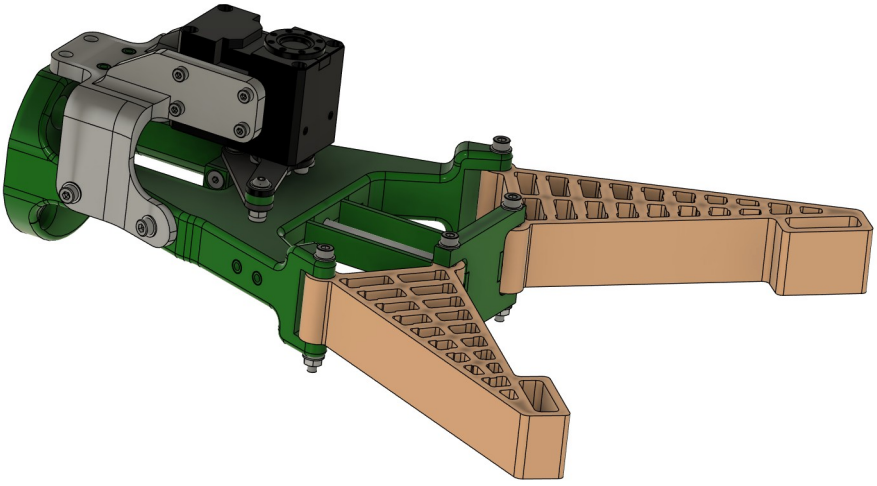


6. **Verify motion.**
   Check that all joints allow smooth motion without friction or backlash.

Mount the fingers

1. **Attach each finger to the body.**
   Use M3 screws to fasten the finger to the body. One mounting hole is for the body, and one for the guide plate! Don’t forget washers on both ends!

2. **Attach each finger to the guide plate.**
   Use M3 screws to fasten the finger to the guide plate. Don’t forget washers on both ends!



Manual motion test

Before powering the motor, manually rotate the crank to verify:

- smooth motion of the slider along the guide
- symmetric actuation of the fingers

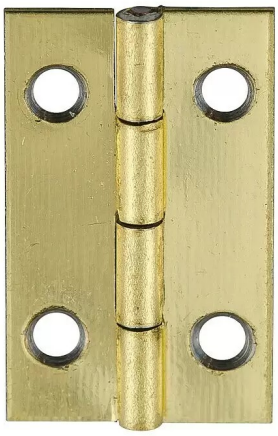
If you experience friction or resistance at this stage, check whether the crank–connecting rod joint is overtightened or if the linear ball bearings are not properly seated in their slots.

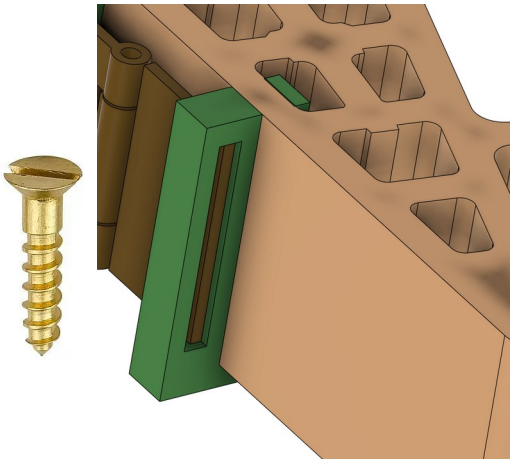
4. Serial Chain Hinge Support

The serial chain hinge support is designed to reinforce the soft Fin-Ray finger structure while maintaining its flexibility. It consists of standard mini door hinges connected via custom 3D-printed rectangular links. This structure passively supports the finger during horizontal loading without impeding bending.

Step 1: Prepare the Hinge Chain

- connect standard 30 x 19 mm steel door hinges using the 3D-printed rectangular connectors





- Ensure all connections allow free sliding of hinges inside the connectors! rotation between hinges! This is an important feature during extension and contraction of the fingers.

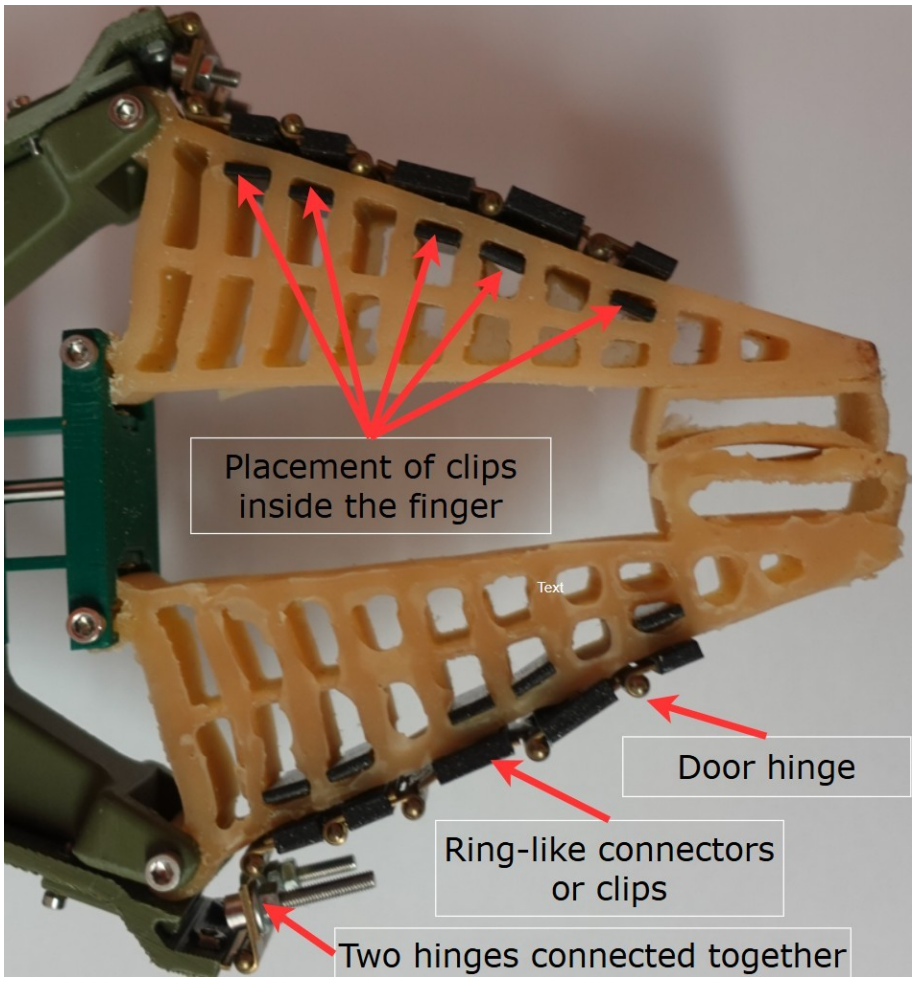
- Due to limited space near the finger base, two hinges may be fastened together without a connector at the end of the chain!

Step 2: Attach to the Finger

- Clip or screw the assembled hinge chain to the **outer side** of the Fin-Ray finger.

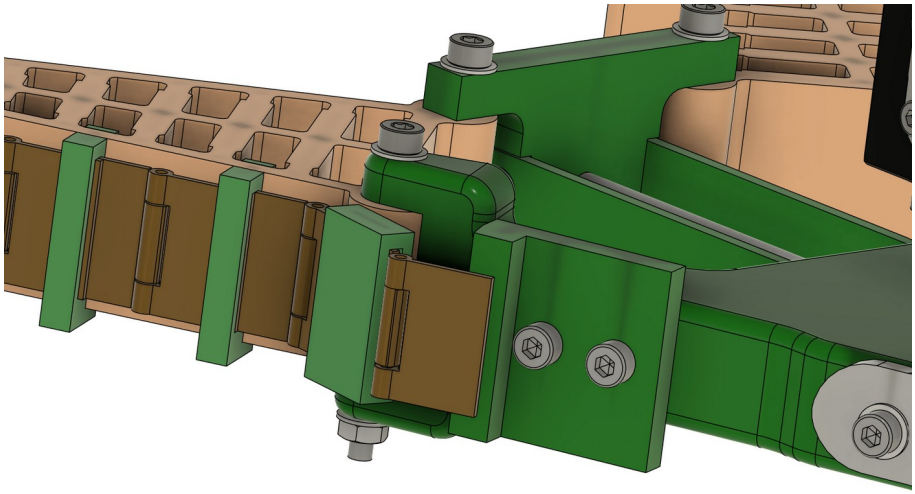
- Check that the chain remains flexible and can **expand and contract** as the finger bends.

- Ensure secure attachment at multiple points along the finger for stable reinforcement. Use the image below as a reference!



Step 3: Secure to the Gripper Body

- Use chain mount to connect to the last hinge in the chain and bolt it directly to the main frame of the gripper.

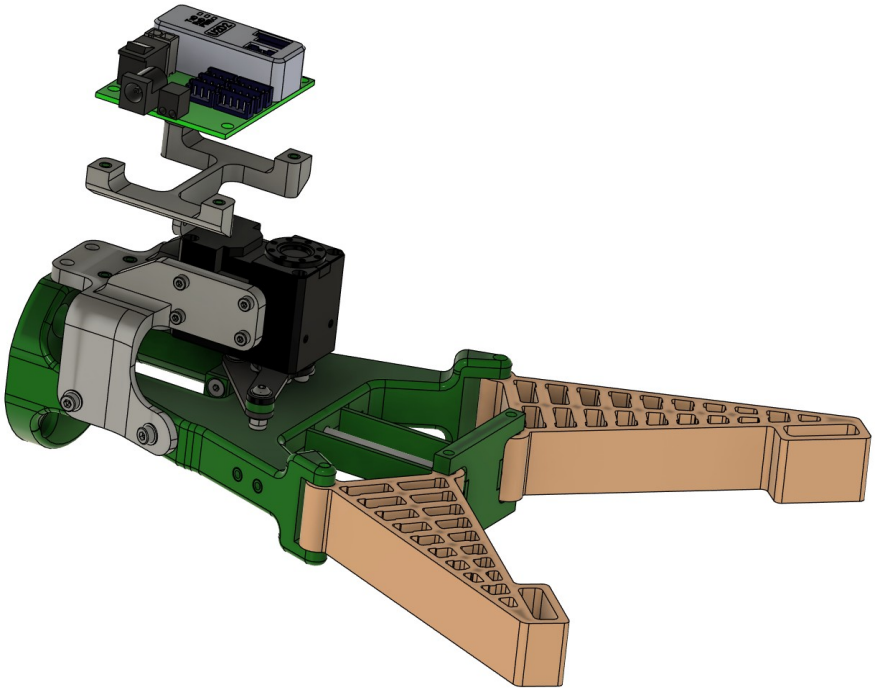


- Verify that the connection is firm and that the entire hinge structure moves smoothly with finger deformation.

5. Final Assembly

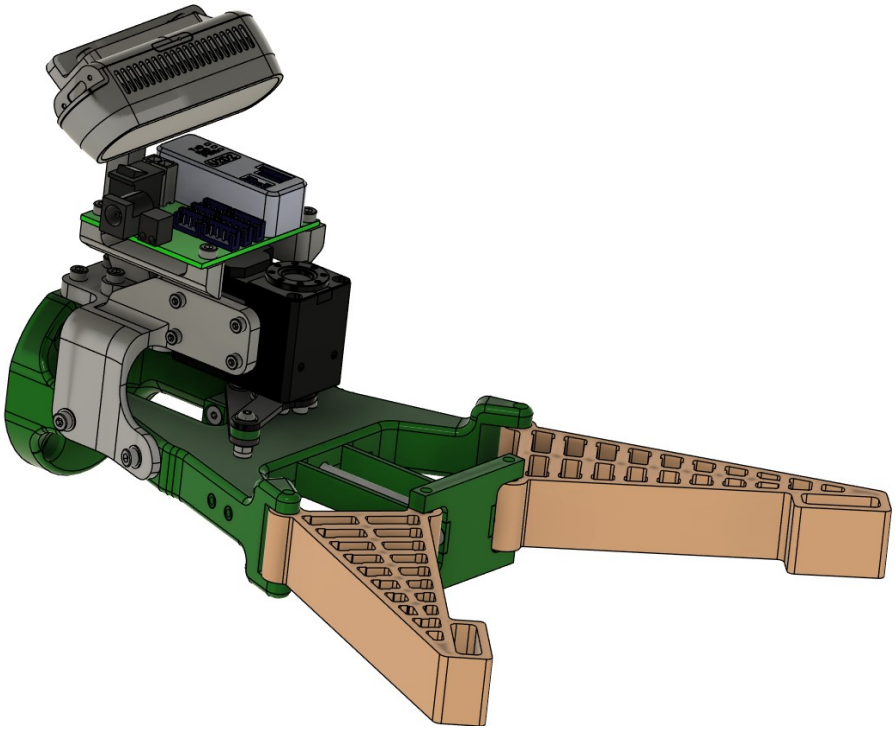
Attach the U2D2 Power Hub

- Mount U2D2 carrier to the motor adapter.
- Mount U2D2 Power Hub to the U2D2 carrier. Ensure that the USB connector looks in another direction than fingers.



Attach the Camera

- Mount the **Intel RealSense D435** camera to the designated top bracket using screws or fasteners provided.
- Verify that the **field of view (FOV)** includes both fingers and the expected workspace for visual feedback.



Cable routing

- Connect the motor power cable to the U2D2 Power Hub.
- Connect the USB cable to the U2D2 Power Hub.
- Make sure that the U2D2 Power Hub and Dynamixel motor are connected according to the manufacturer’s documentation.
- Route the **motor cables** and **USB cable** from the RealSense camera “behind” the gripper.
- Use **zip ties** to secure the wiring neatly and prevent any interference with moving parts.

System test

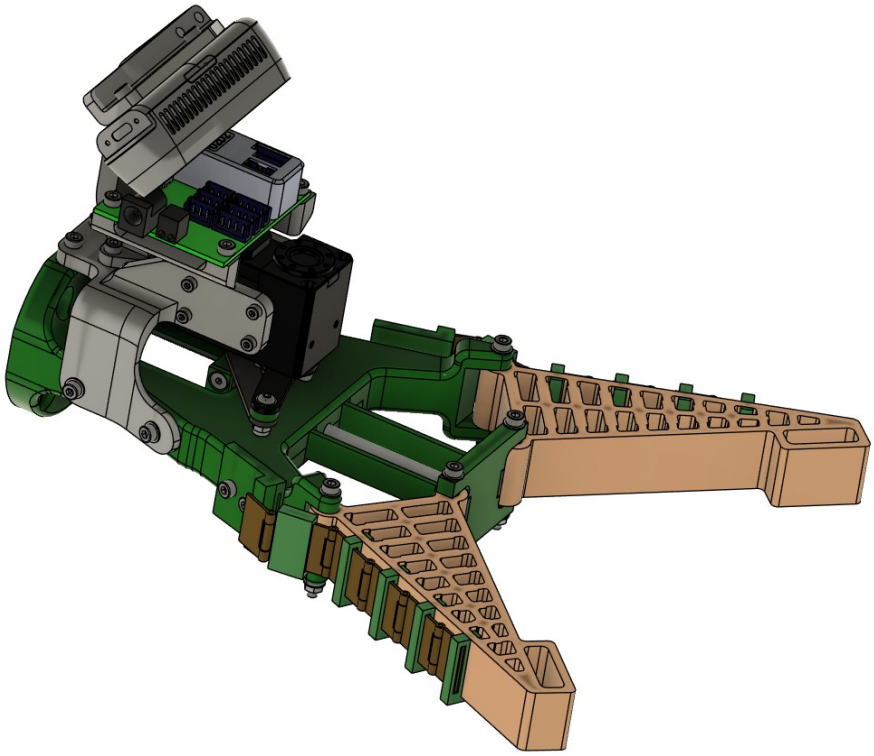
- Power the system and perform a **full actuation cycle** to verify proper finger movement and mechanism alignment.

- Check that:

    - The fingers close symmetrically.
    - There is **no friction or binding** in the motion.
    - The camera streams correctly.

- Confirm that **all bolts and connectors are properly tightened**.

Congratulations!
Your SofIA gripper is fully assembled and ready for deployment.



Note: If you have any questions, encounter issues during assembly, or are interested in collaboration opportunities, please feel free to contact us:

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