Open Parametric Hand Build Guide
Version 1

Kieran Gilday
github.com/kg398/100_fingers

July 2025

Contents

Introduction

A more comprehensive build guide to accompany the basic instructions in README.md and video guide.

Summary of files

- /OpenSCAD: scripts for generating hands with OpenSCAD. parameters.scad for demo use and parameters for generating example hands
- /STLs: 3D files for 3D printable parts
- /STLs/hands: three example hands generated from parameters.scad and example generated for visualisation (no_lig)
- /STLs/actuation_box: 3D files for three examples of modular actuation (1 degree-of-freedom(dof)/synergy, 2 dof/synergy, 1 dof with switching modulation)
- /STLs/manual_handles: 3D files for manual lever actuation and handles for 1 and 2 dof actuation boxes
- /media: images from publication (in progress)
- /build_guide: build guide PDF and videos

List of publications

- Gilday, K., Sirithunge, C., Iida, F., & Hughes, J. (2025). Embodied manipulation with past and future morphologies through an open parametric hand design. Science Robotics, 10(102), eads6437. /10.1126/scirobotics.ads6437 (arxiv: /10.48550/arXiv.2410.18633)
- Carlet, R., Gilday, K., & Hughes, J. (2025, April). Behaviour Range Optimization of the Dexterous Robotic Open Parametric Hand. In 2025 IEEE 8th International Conference on Soft Robotics (RoboSoft) (pp. 1-7). IEEE. /10.1109/RoboSoft63089.2025.11020976
- Gilday, K., Pyeon, D., Dhanush, S., Cho, K. J., & Hughes, J. (2024). Exploiting passive behaviours for diverse musical playing using the parametric hand. Frontiers in Robotics and AI, 11, 1463744. /10.3389/frobt.2024.1463744

0 Getting Started

The build guide follows the assembly of the default anthropomorphic hand (4 fingers, 1 thumb), single DoF actuation box, and manual handle. The exact version used in this guide is ?release_v?[1].

0.1 Bill of materials

Full list of materials for default hand, 1 DoF actuation box, and manual hand:

Part	Description	Quantity
Polypropylene filament	Single-piece printed hand	80 (g)
M2x4 countersunk bolts	Tendon anchors	21
Braided fishing line, ∼0.2 mm diameter, >20 kg load	Tendons	10 (m)
PLA filament	Actuation box printed parts	50 (g)
Extension springs (l: 10–15 mm; k: 0.1–1 N/mm)	Passive tendon mounting and SEA	26
15x5x4 mm flanged bearing	Actuation pulley mounting	2
50x4 mm smooth rod	Passive tendon bearing surface, e.g. aluminium	3
60x1.5mm smooth rod	Passive tendon pins, e.g. fibreglass	3
Braided fishing line, ∼1 mm diameter, >80 kg load	Actuation tendon	0.3 (m)
M2x4 countersunk bolts	SEA spring mount	5
M2x4 caphead	Box assembly, passive tendon anchors, t-select	3+21+1
M2x8 caphead	Box assembly and active tendon anchors	6+6
M2x10 caphead	Box assembly and SEA pins	2+2
M2 nut	Passive and active tendon anchors	21+5
M3x6 caphead	Box assembly, wrist and handle mounting	6+4+4
M4x12 grub screw	Hand mount	2
M5x16 caphead	Pulley shaft	1
PLA filament	Manual handle printed parts	100 (g)
140x4 threaded rod, steel	Tendon anchor and lever backbone	1
M4x25 caphead	Anchor locking pin	1
M4 nut, square	Tendon anchor	4
M5x25 caphead	Lever shaft	1

0.2 Printing files

Hand printing

Hands can be printed via commercial FDM printers (Prusa/Creality/Craftbot/Raise3D tested). General printing requirements are: large build volume and semi-flexible materials. Ideal hand properties with dual extrusion nylon filament and support material. Nylon printing is challenging for most printers, therefore polypropylene (PP) printing is recommended for good living hinge properties and relative ease of printing with a single extruder and standard temperatures. Print orientation is critical (palm should face down with fingertips closest to build plate and all ligament pairs flat relative to the build plate). Tree/organic support is recommended for easy removal around delicate ligaments. Minimal post-processing is needed to ensure pulleys are all clear of material. See Fig. i for example in Prusa Mk3/4.

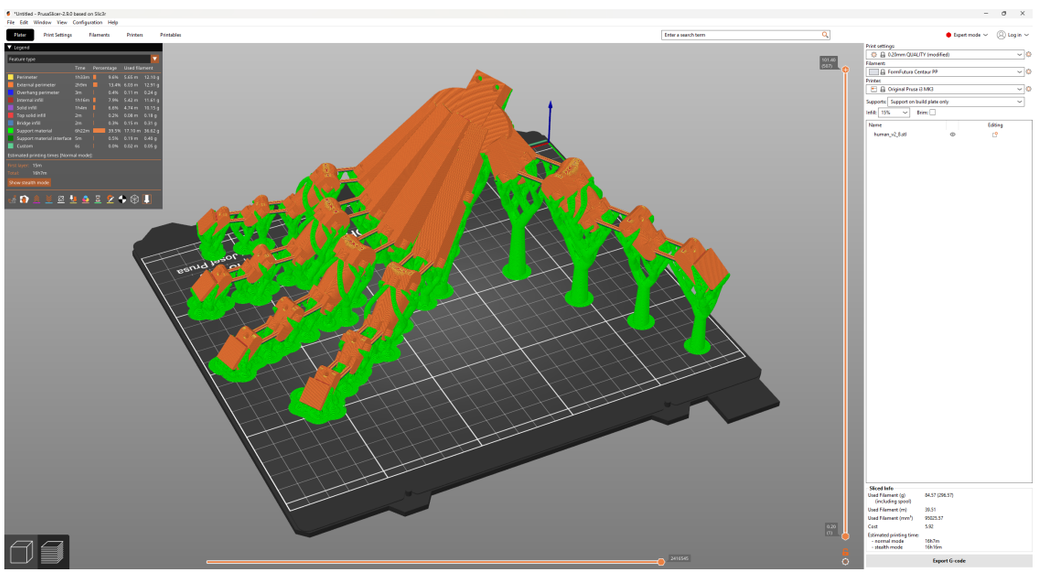

Figure i: Single-piece hand. Note ligaments oriented in x-y plane. Red = hand. Green = organic support.

[1] 2 DoF, switching, and 2 DoF handle are not updated in this release

SLS printing is also suitable. Only polyamide (PA2200) has been tested, resulting in stiffer bones than polypropylene and a cleaner print. Orientation is less critical.

Polypropylene printing tips

PP offers superior properties compared to standard 3D printing materials for this application with high toughness and excellent layer adhesion. PP adheres poorly to everything except itself, including most printer build plates. First layer adhesion issues are overcome by placing a layer of tape containing PP (most clear packaging tapes) on the build plate.

Follow manufacturers guidelines for printing PP, generally: 220–240°, bed 60°, 100% cooling, no heated enclosure.

Support material and bridge settings may need tuning depending on filament and printer model. Some test prints of single fingers or joints are recommended to find a balance of print quality and ease of support removal. Organic/tree type support is recommended. Lower print temp and denser support gives less warping and more reliable ligament printing.

Actuation printing

Actuation box and handles are printed with standard profiles in PLA. See Fig. ii for example in Bambu X1C.

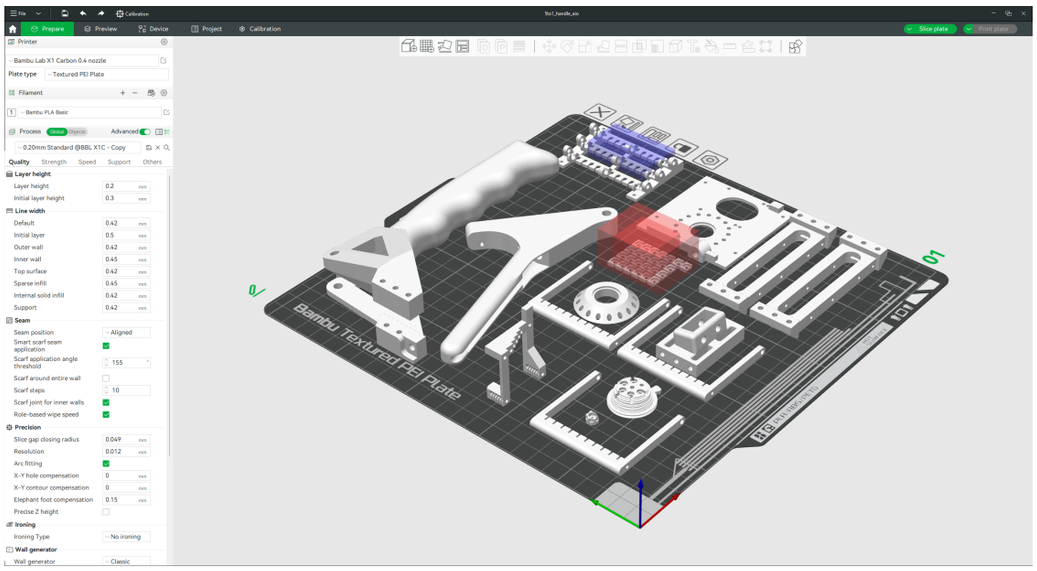

Figure ii: Actuation box and manual handle parts. Note part orientation. Red = support blocker. Blue = support enforcer.

1 Hand

Figure 1: ..

Figure 1a: ..

1.1 Support material

1.2 Cut tendons

1.3 Anchor bolts

1.4 Knot and rout tendons

Figure 1.1: ..

Figure 1.2: ..

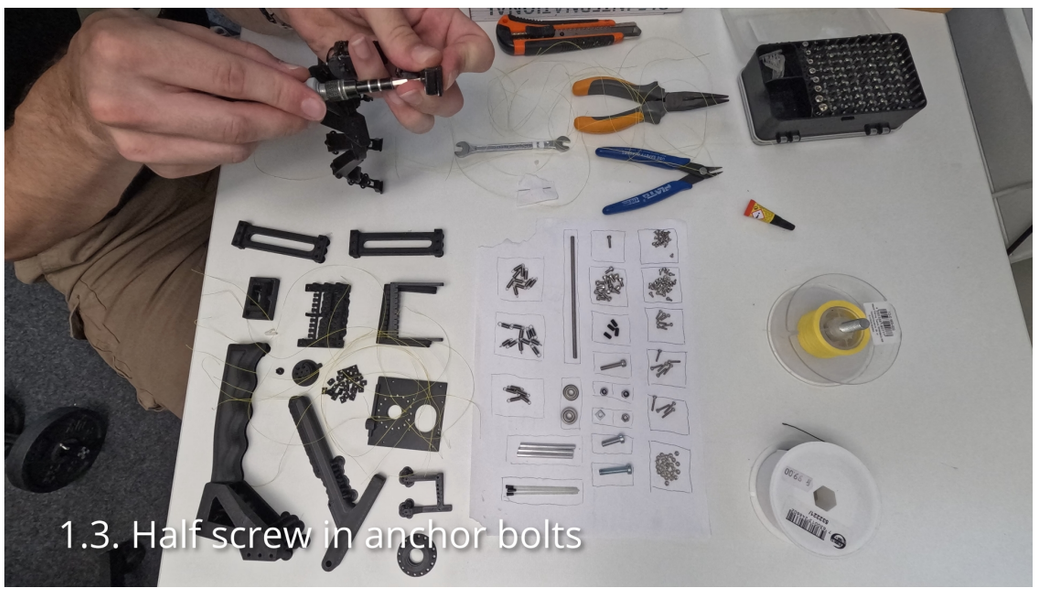

Figure 1.3: ..

Figure 1.4: ..

Figure 1.4a: ..

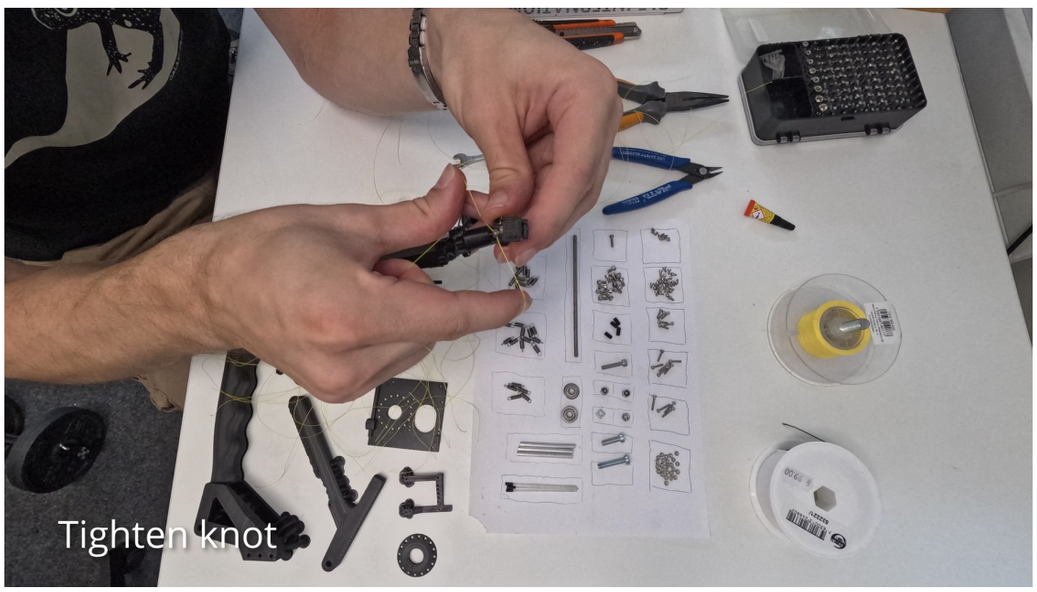

Figure 1.4b: ..

Figure 1.4c: ..

Figure 1.4d: ..

Figure 1.4e: ..

Figure 1.4f: ..

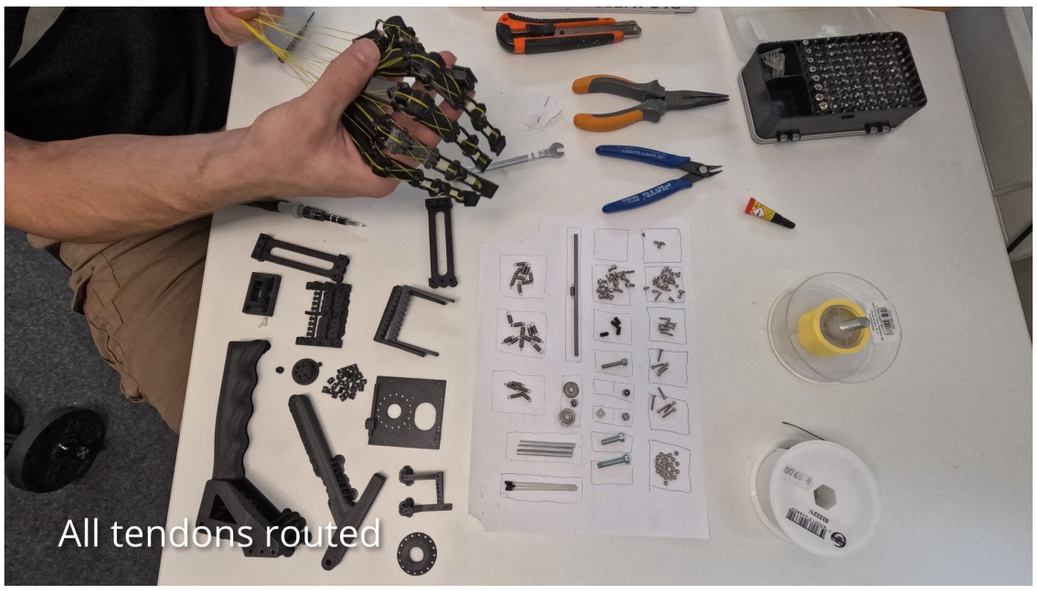

Figure 1.4g: ..

Figure 1.4h: ..

2 Actuation Box

Figure 2: ..

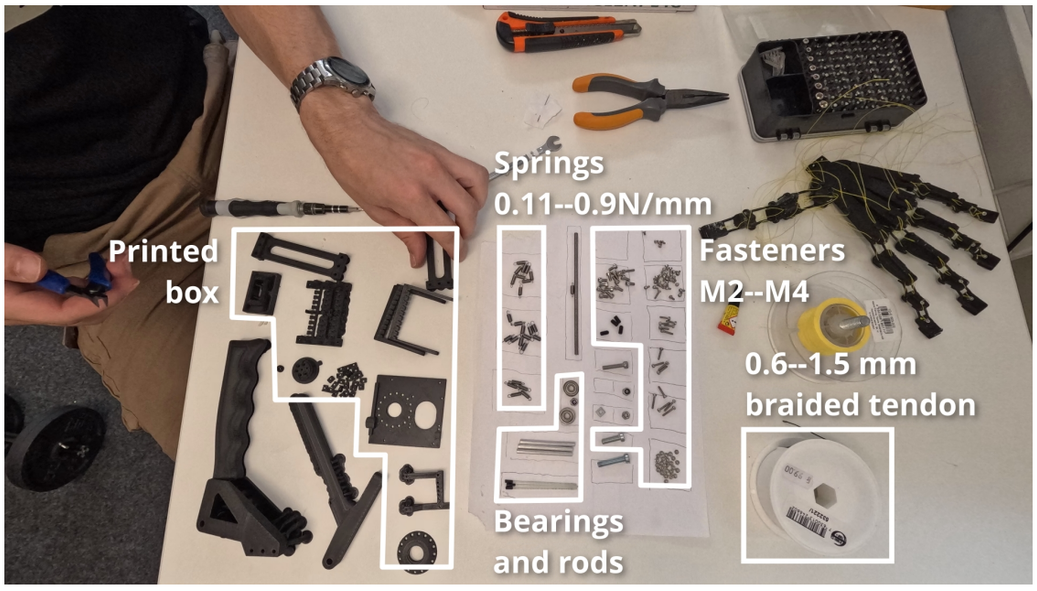

Figure 2a: ..

2.1 Support material

2.2 Hand connector and spring racks

2.3 Spring anchors

2.4 Hand mounting and passive tendons routing

2.5 Active tendon base components

2.6 Actuation pulley

2.7 Passive tendon fine adjustment

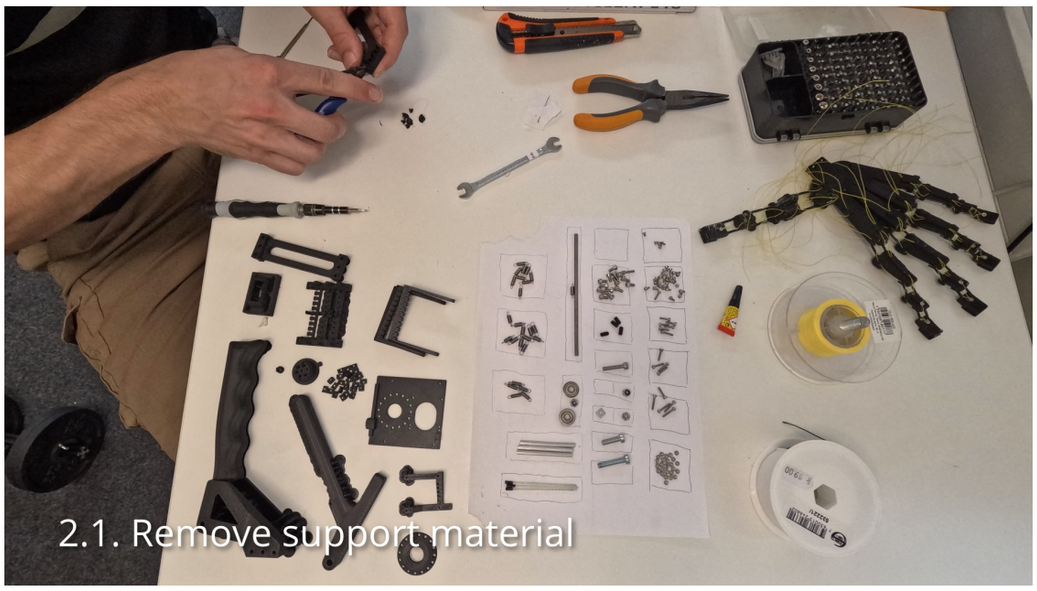

Figure 2.1: ..

Figure 2.2: ..

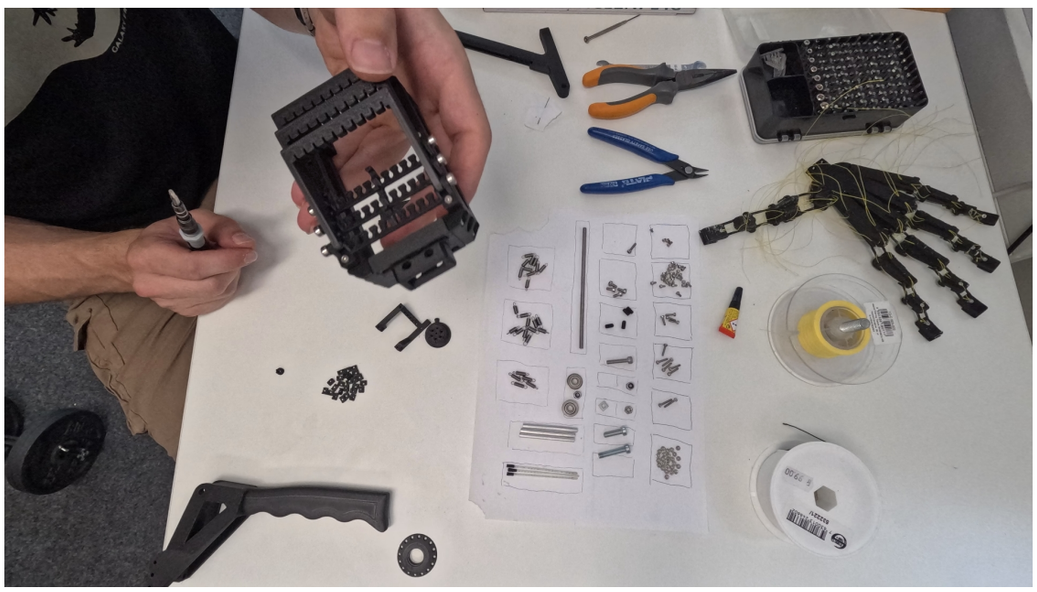

Figure 2.2a: ..

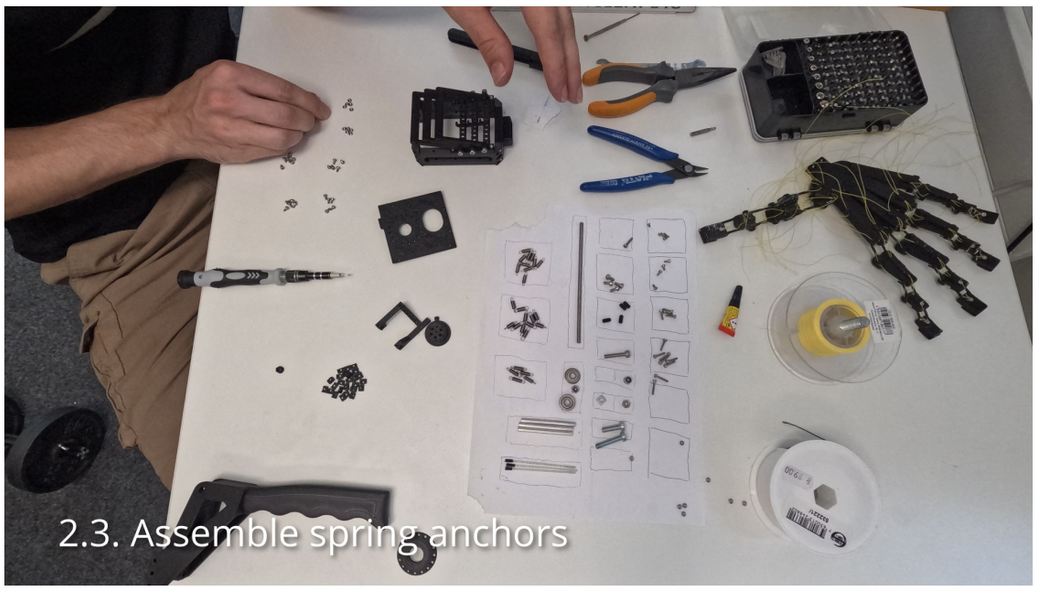

Figure 2.3: ..

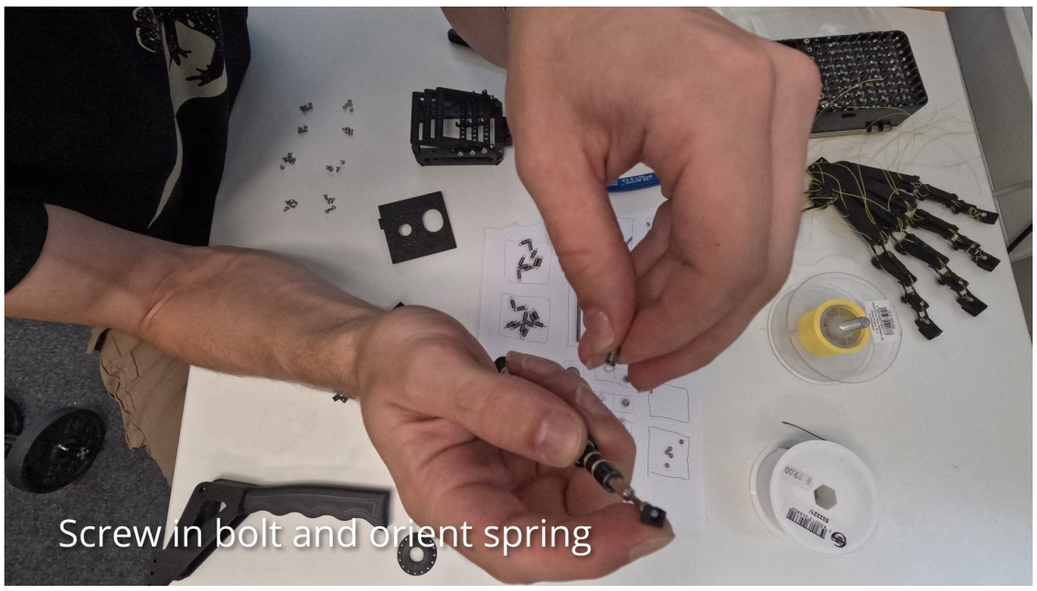

Figure 2.3b: ..

Figure 2.3c: ..

Figure 2.4: ..

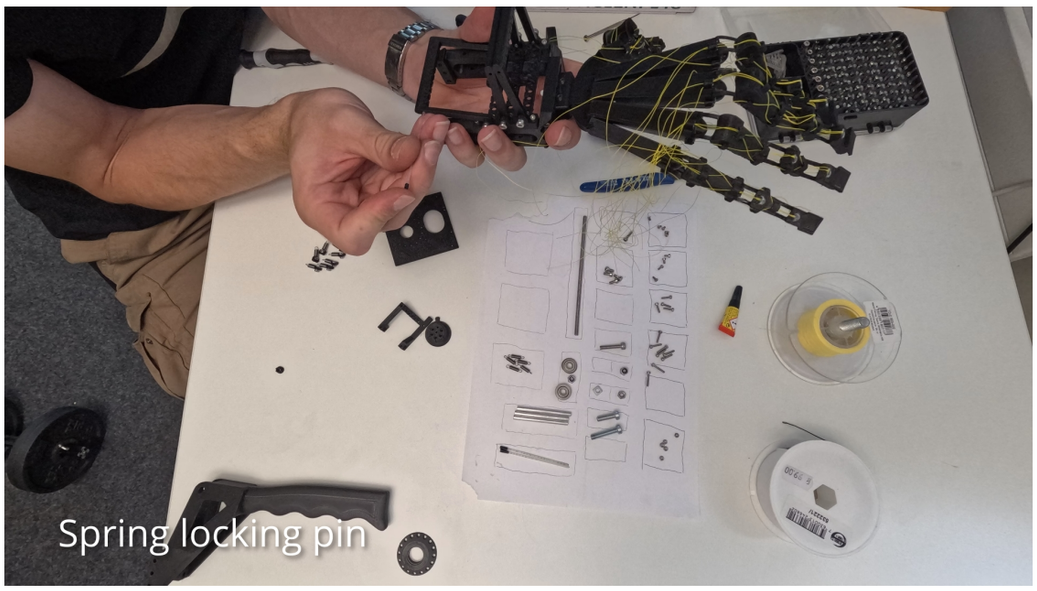

Figure 2.4a: ..

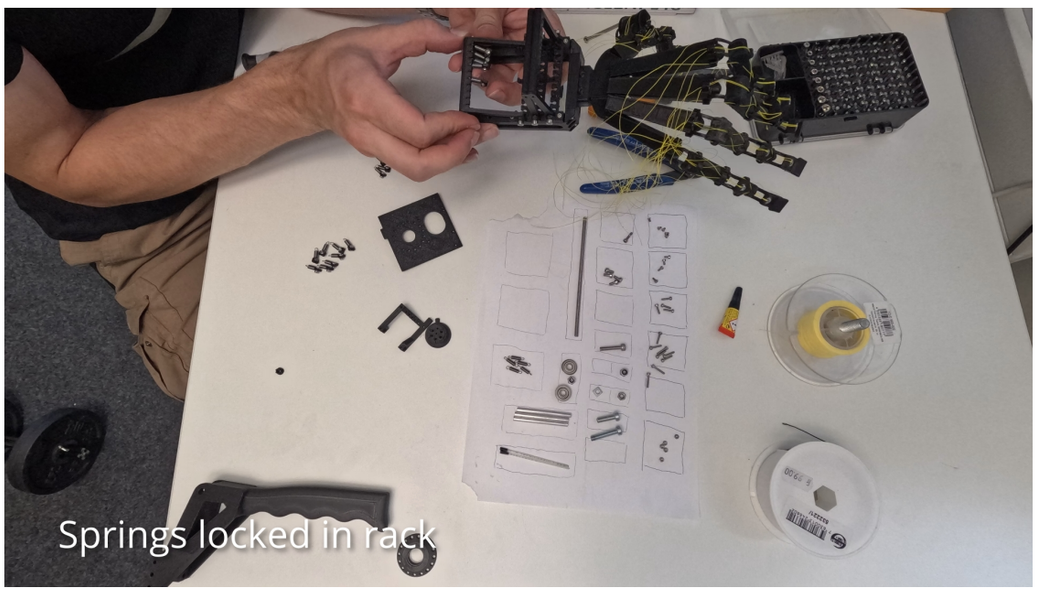

Figure 2.4b: ..

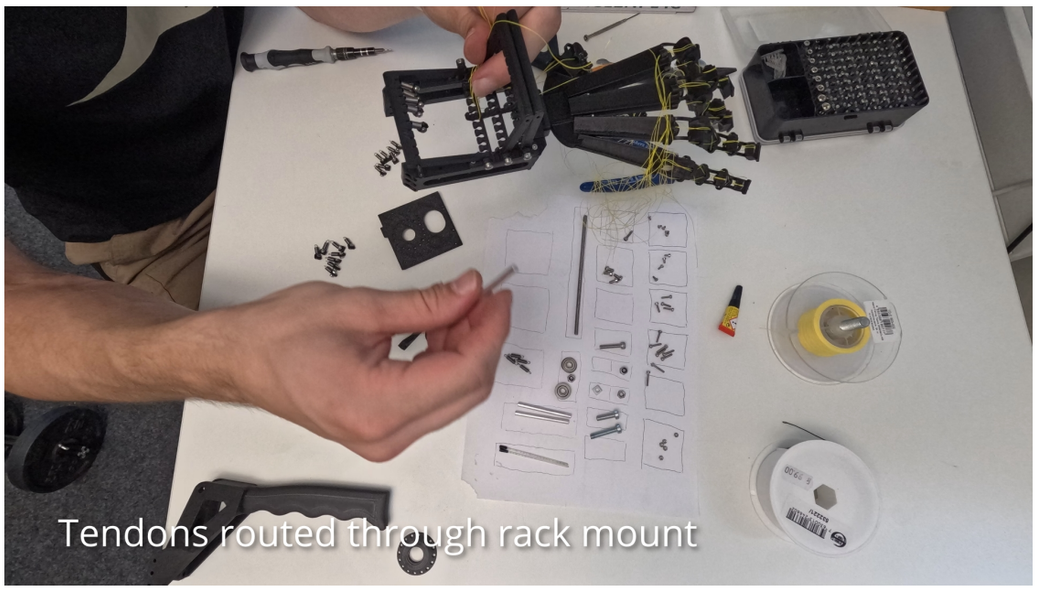

Figure 2.4c: ..

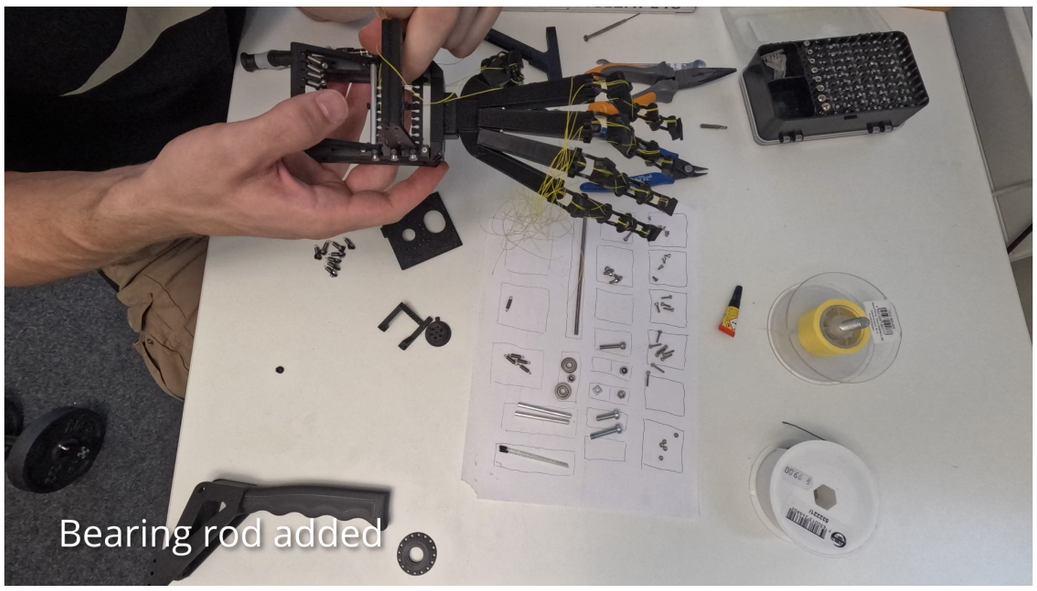

Figure 2.4d: ..

Figure 2.4e: ..

Figure 2.4f: ..

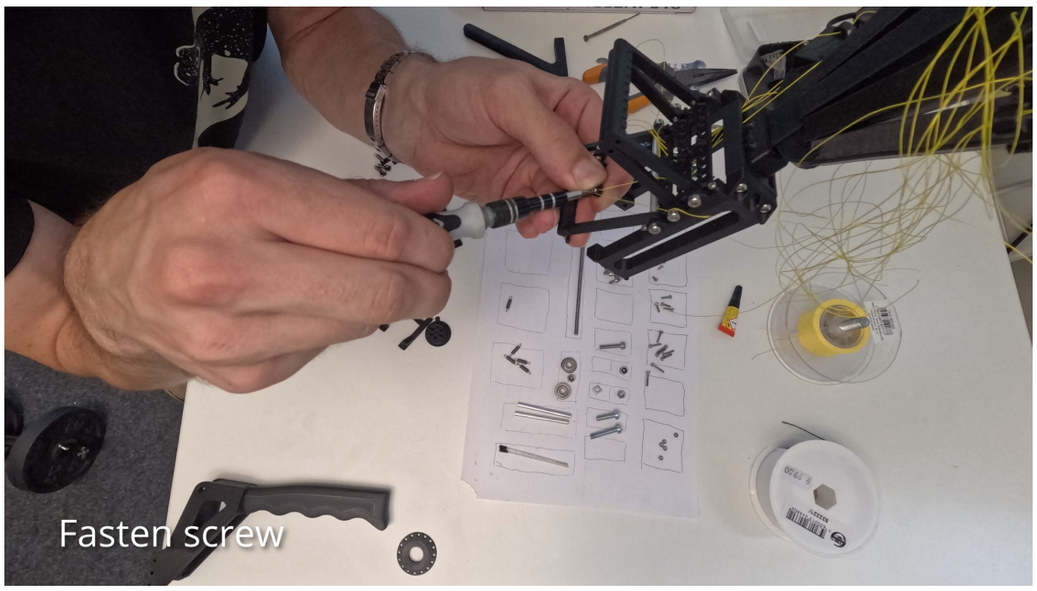

Figure 2.4g: ..

Figure 2.4h: ..

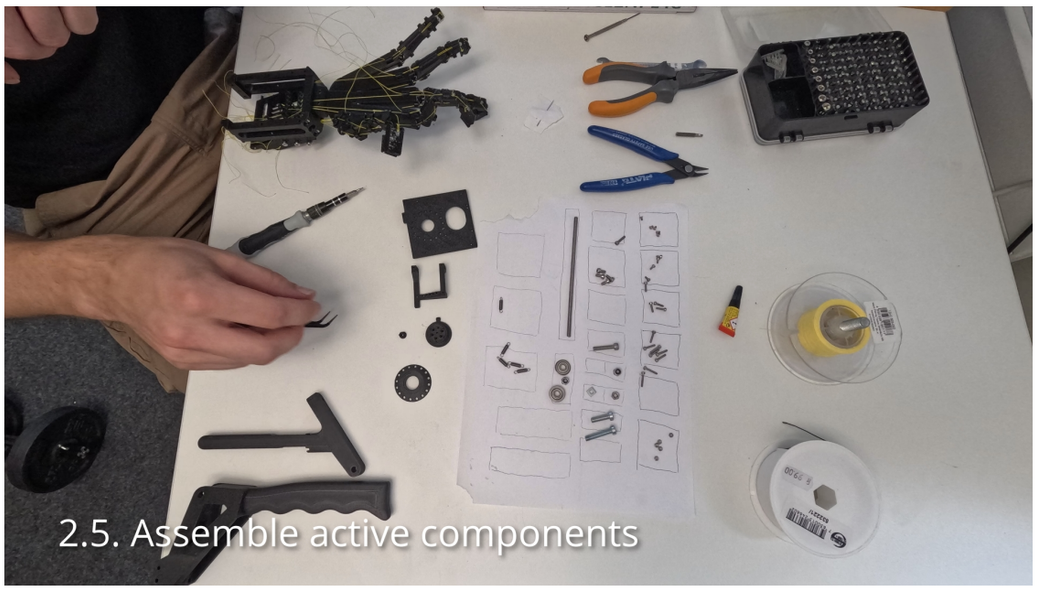

Figure 2.5: ..

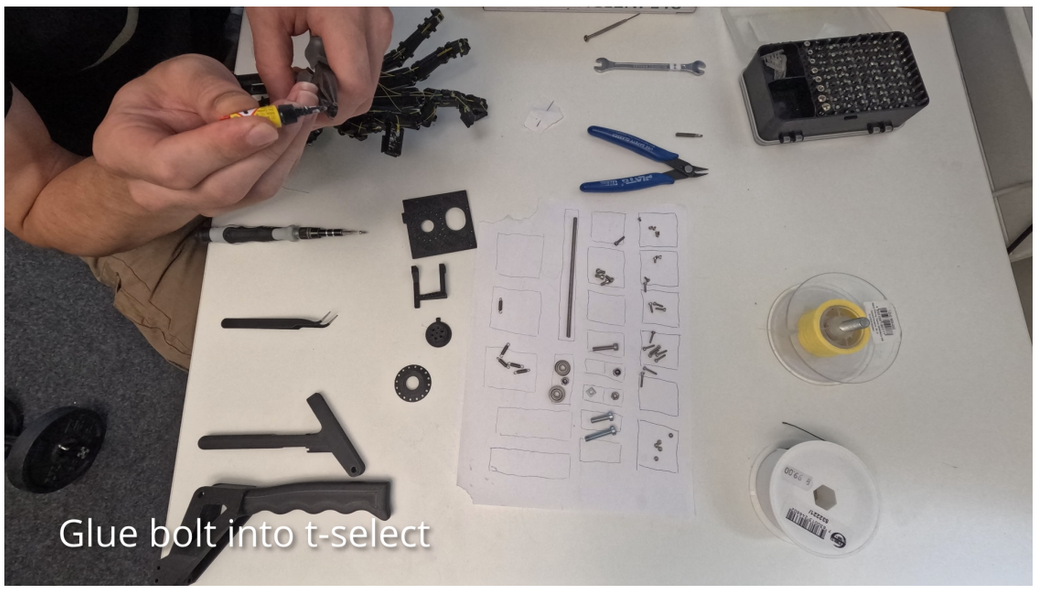

Figure 2.5a: ..

Figure 2.5b: ..

Figure 2.5c: ..

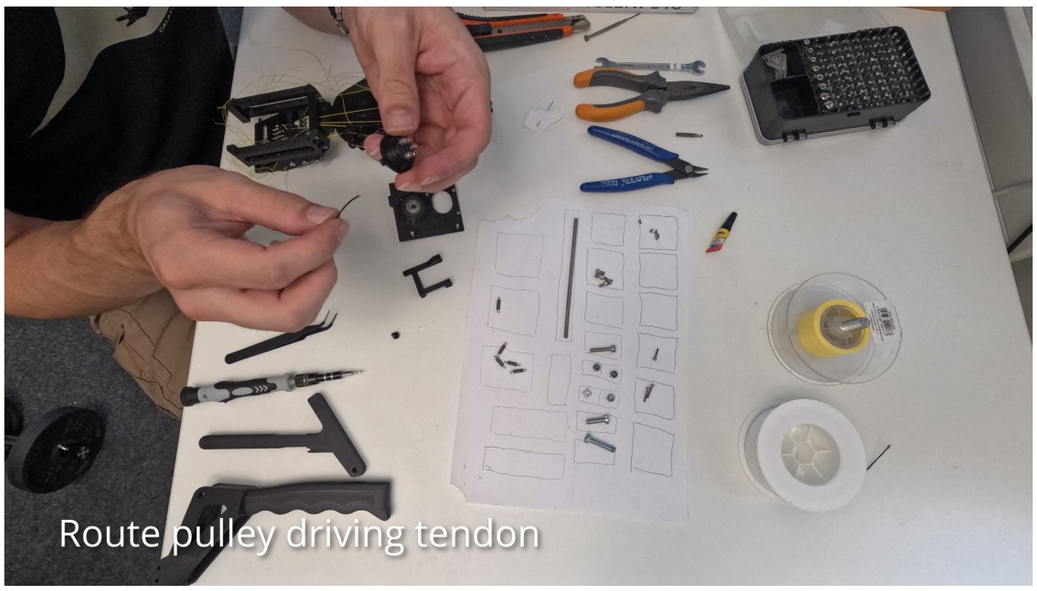

Figure 2.5d: ..

Figure 2.5e: ..

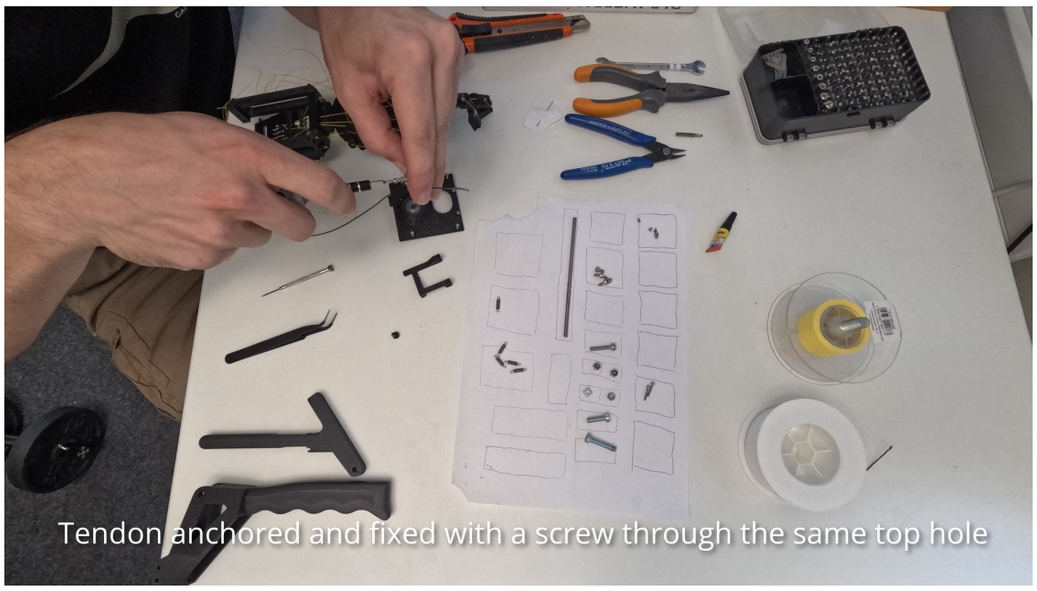

Figure 2.5f: ..

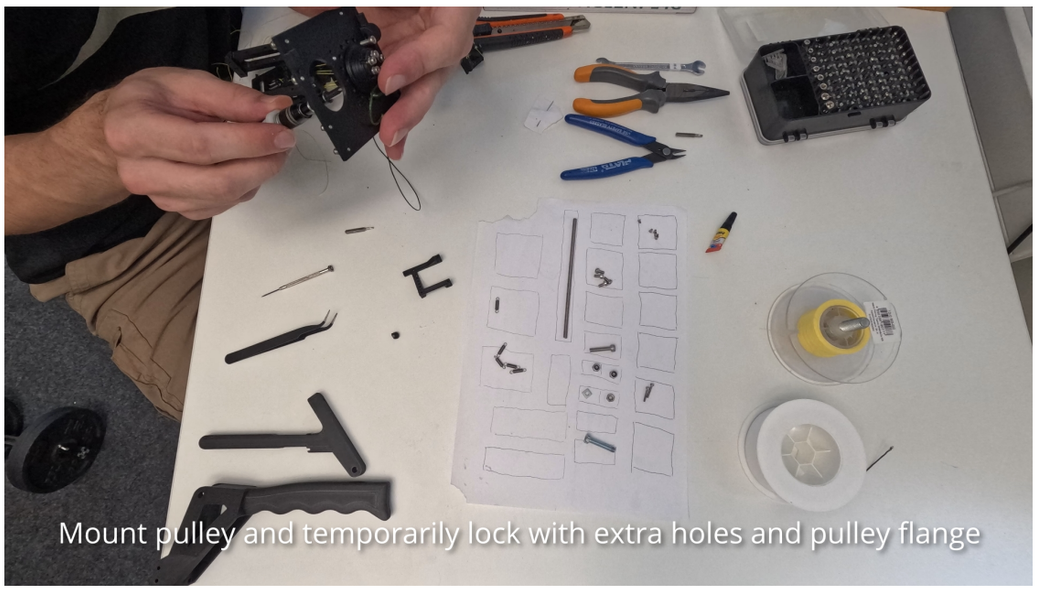

Figure 2.5g: ..

Figure 2.5h: ..

Figure 2.5i: ..

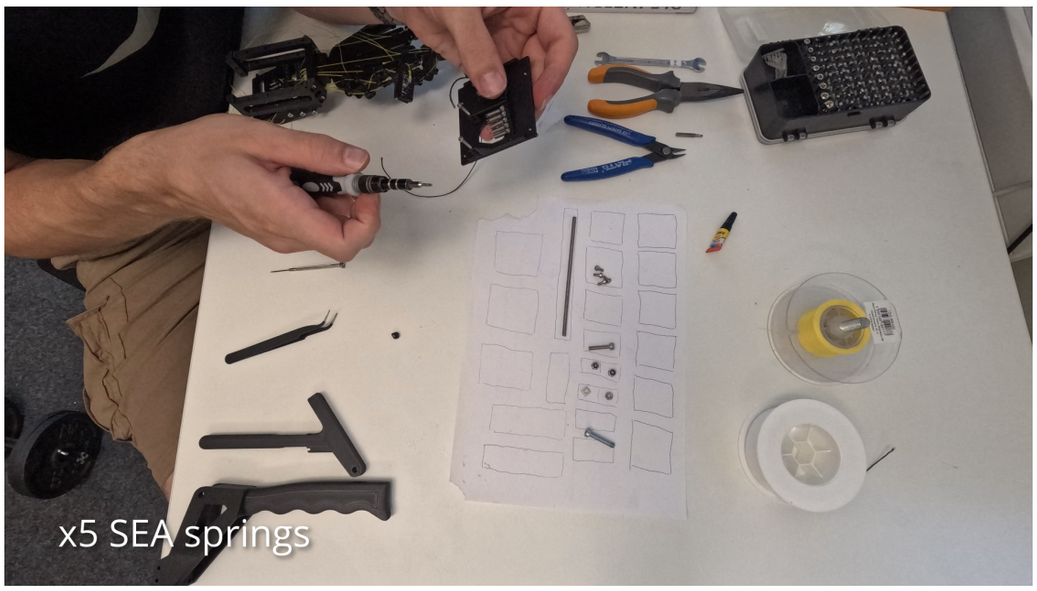

Figure 2.5j: ..

Figure 2.5k: ..

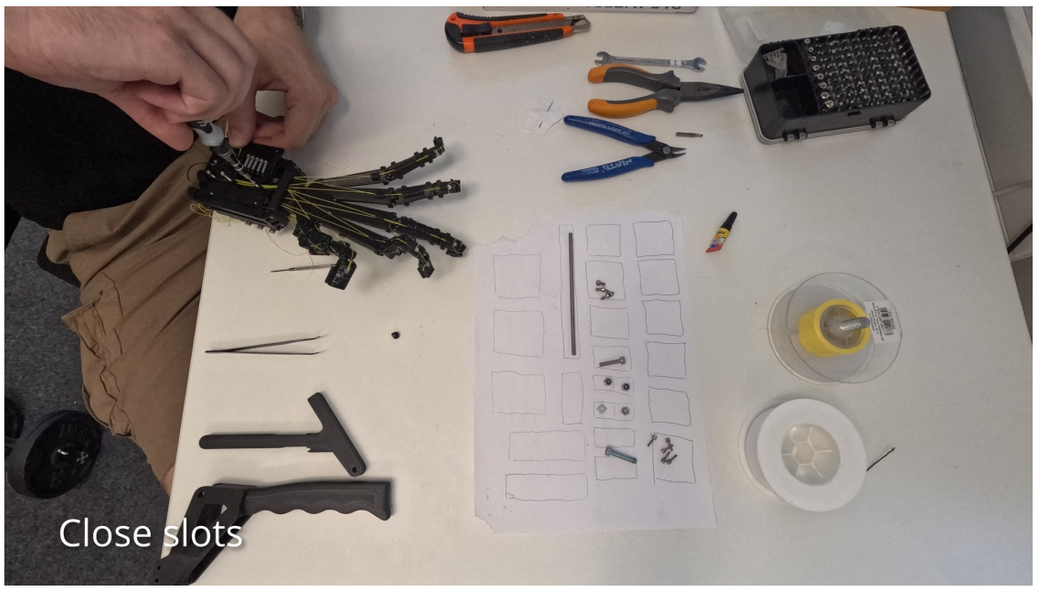

Figure 2.5l: ..

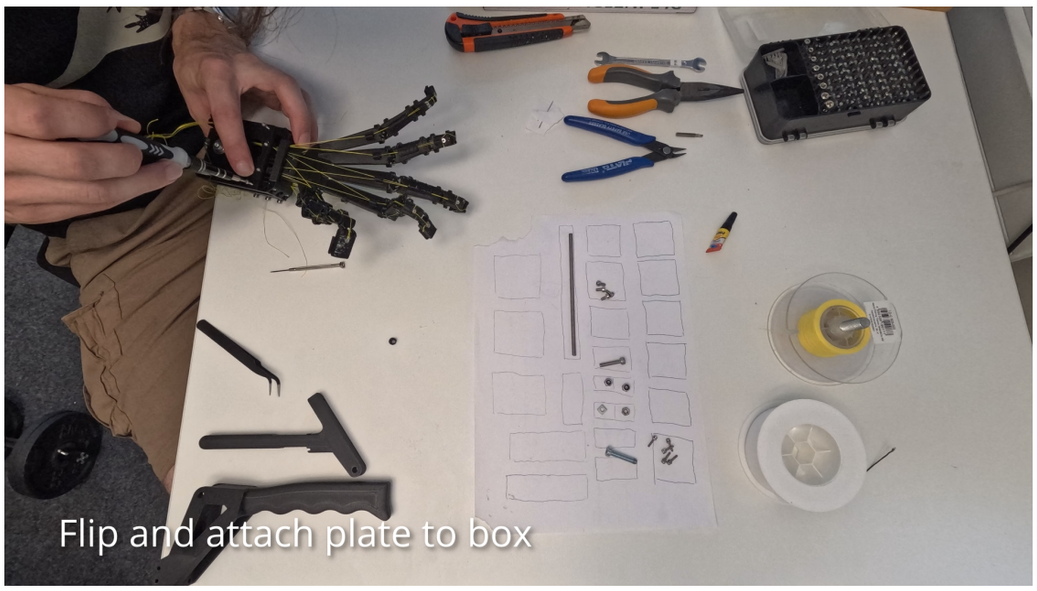

Figure 2.5m: ..

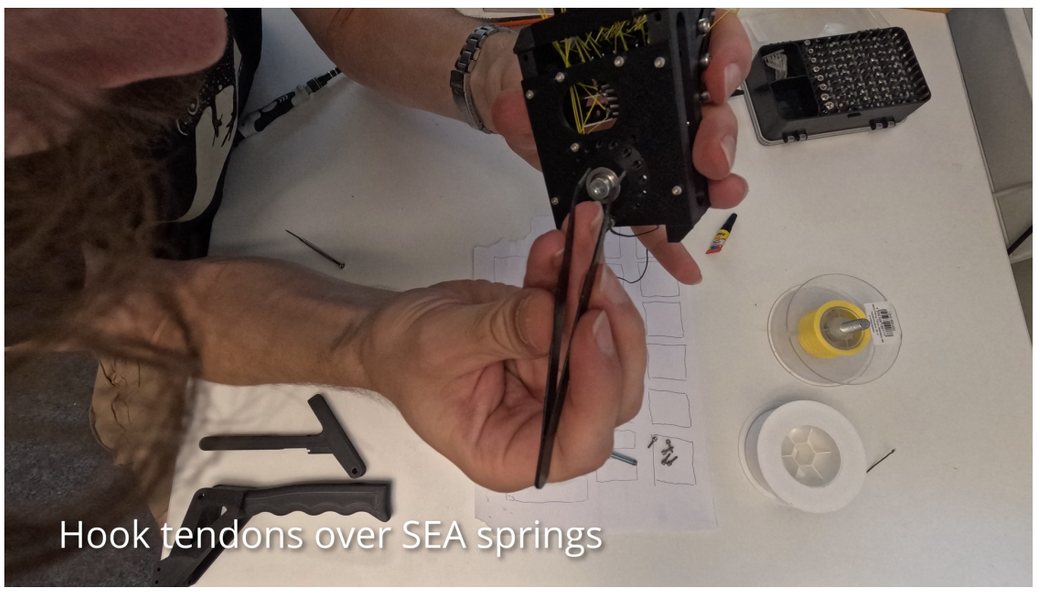

Figure 2.5n: ..

Figure 2.5o: ..

Figure 2.6: ..

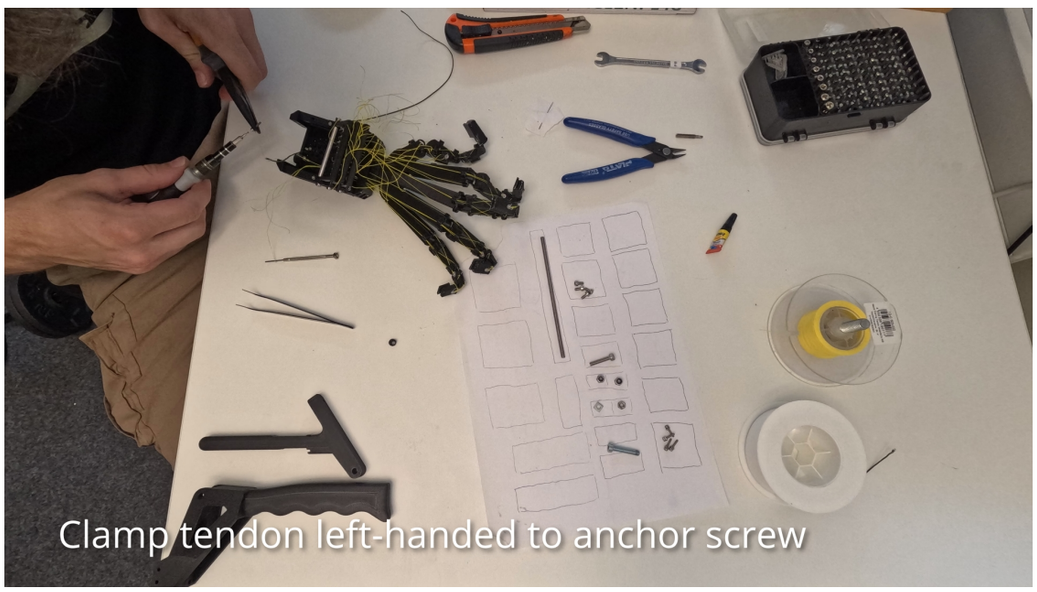

Figure 2.6a: ..

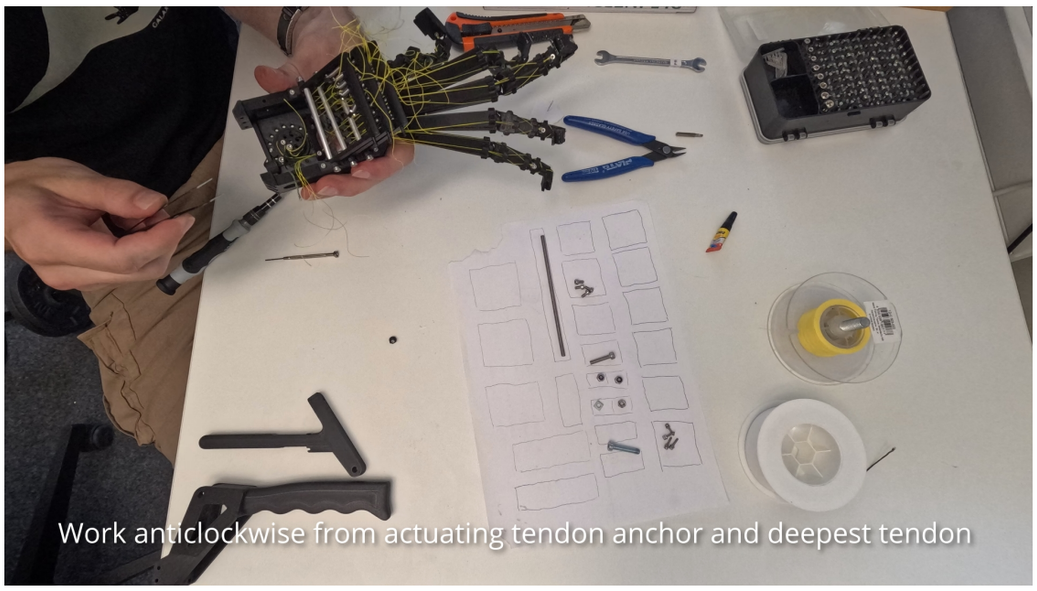

Figure 2.6b: ..

Figure 2.6c: ..

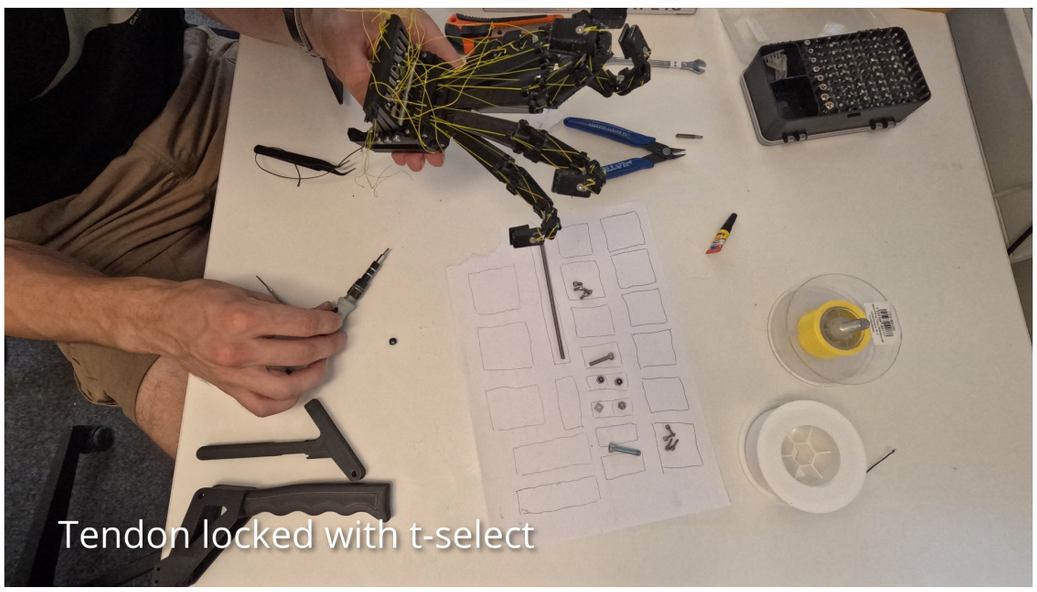

Figure 2.6d: ..

Figure 2.7: ..

Figure 2.7a: ..

3 Manual Handle

Figure 3: ..

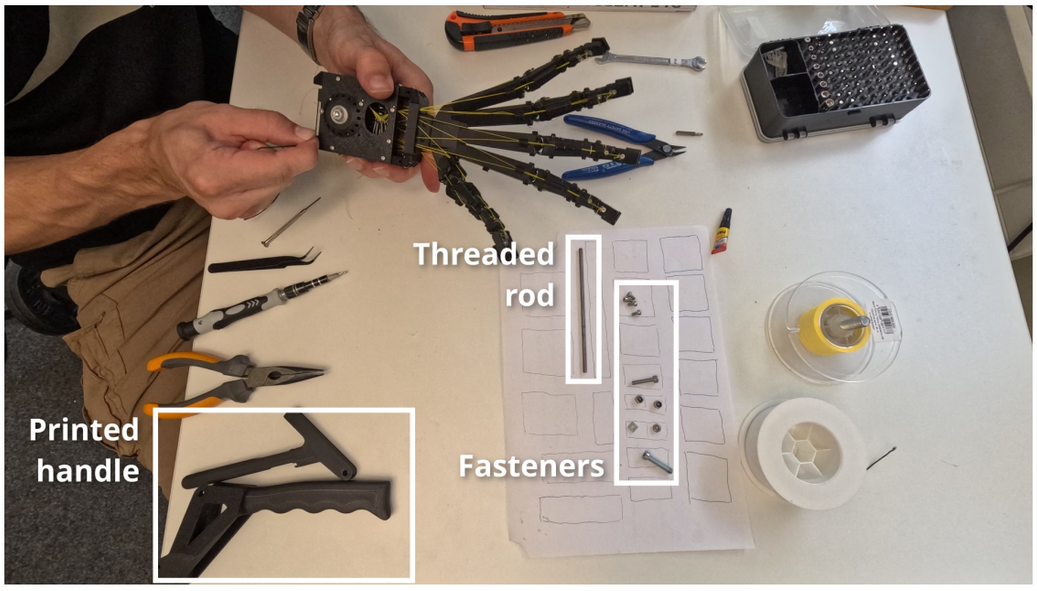

Figure 3a: ..

3.1 Route tendon and connect handle

3.2 Actuation lever

3.3 Active tendon fine adjustment

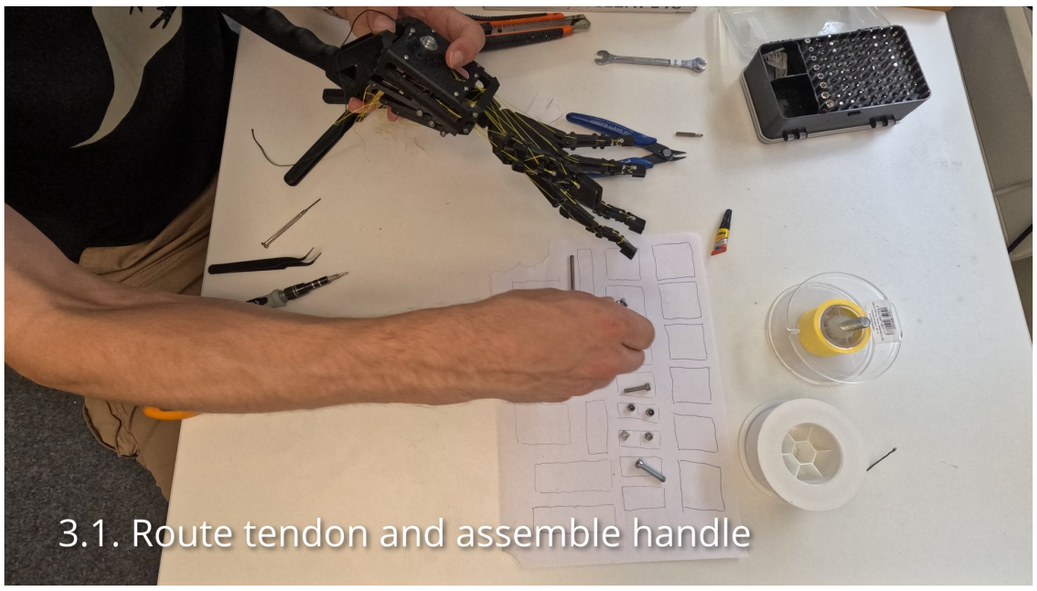

Figure 3.1: ..

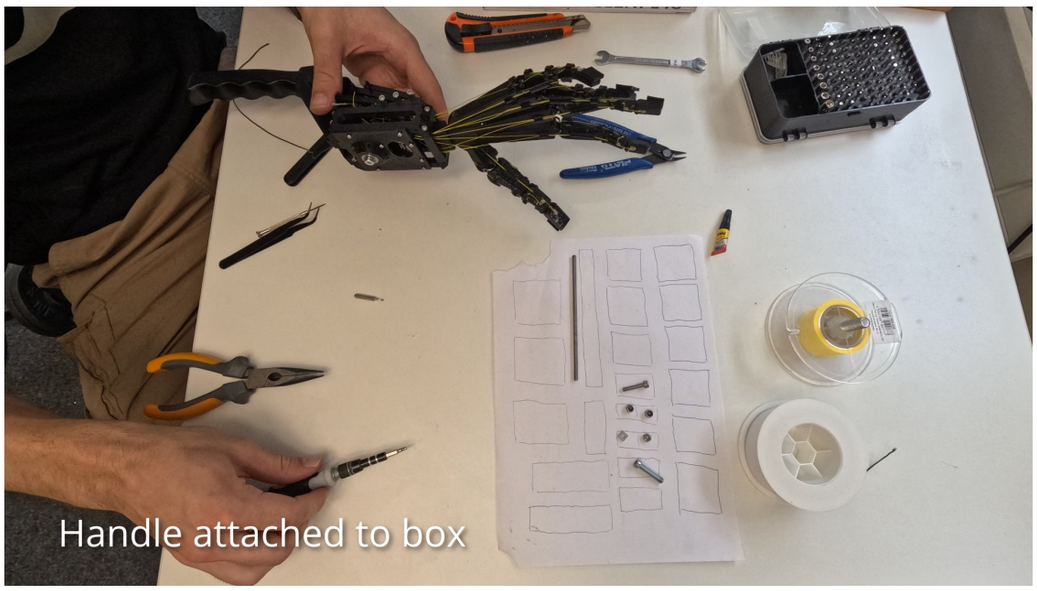

Figure 3.1a: ..

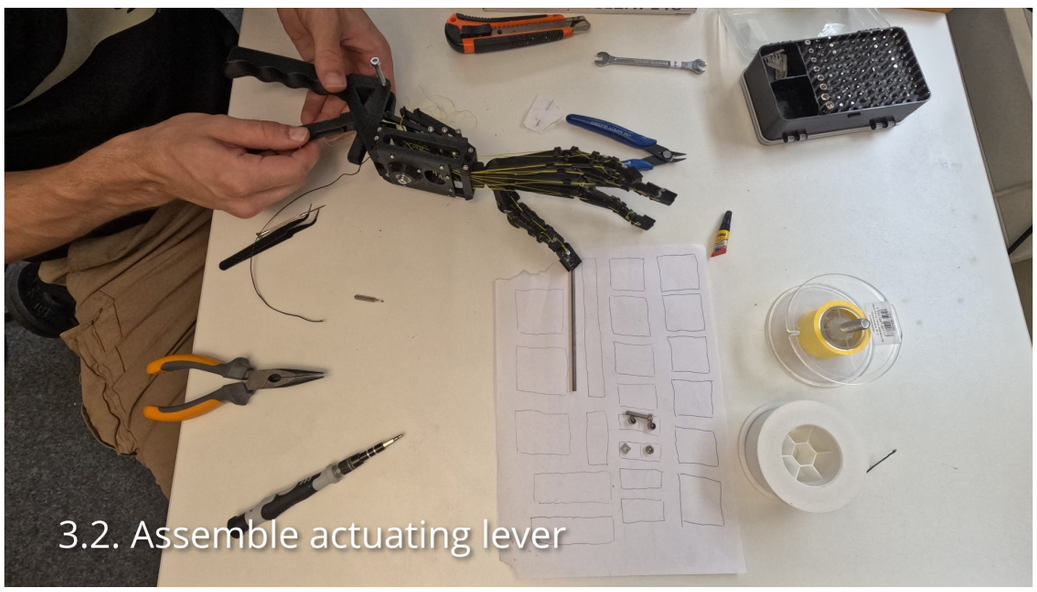

Figure 3.2: ..

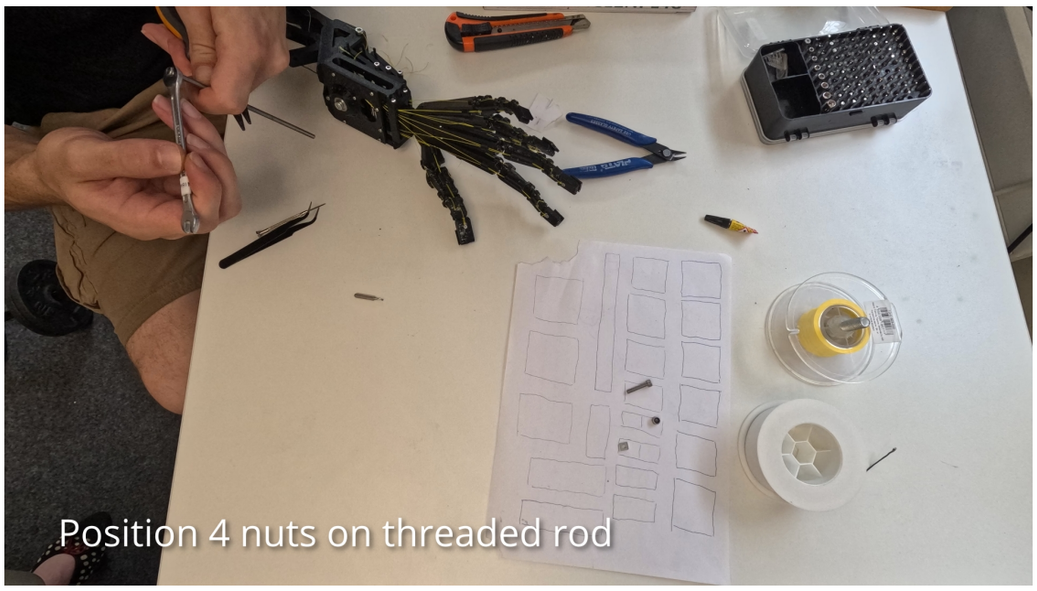

Figure 3.2a: ..

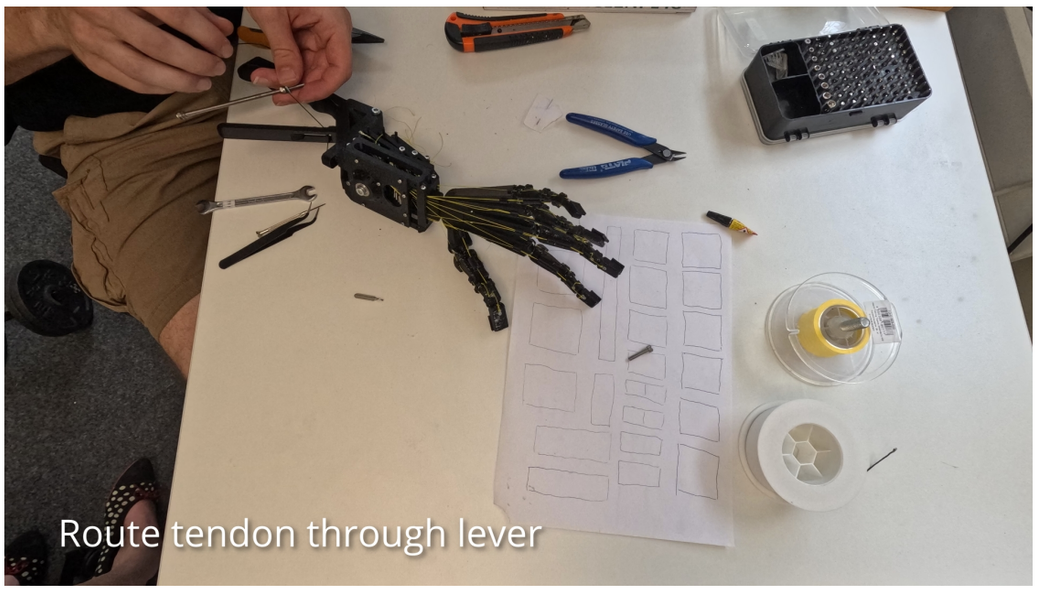

Figure 3.2b: ..

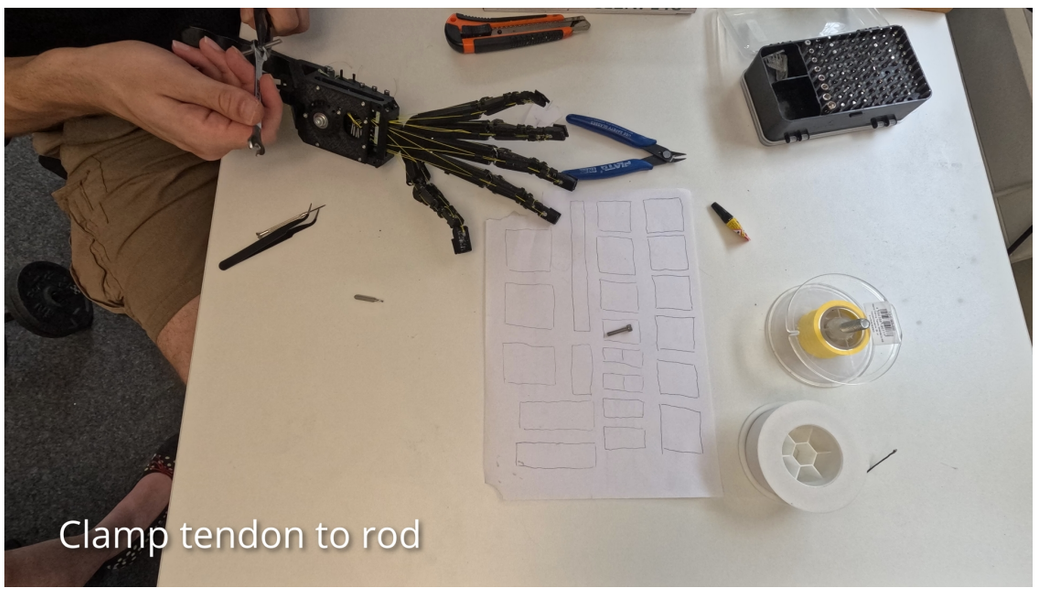

Figure 3.2c: ..

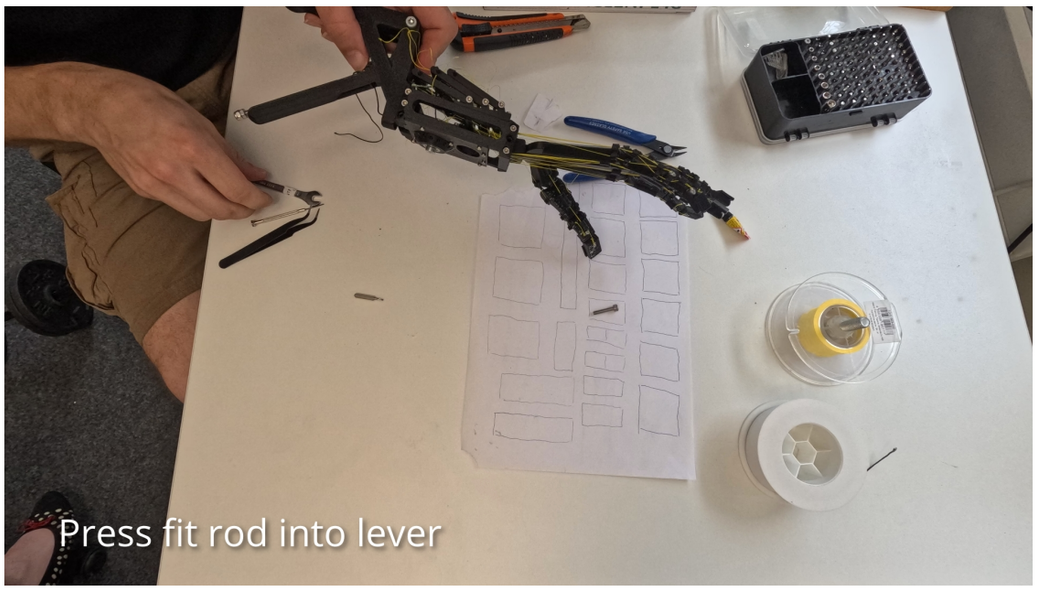

Figure 3.2d: ..

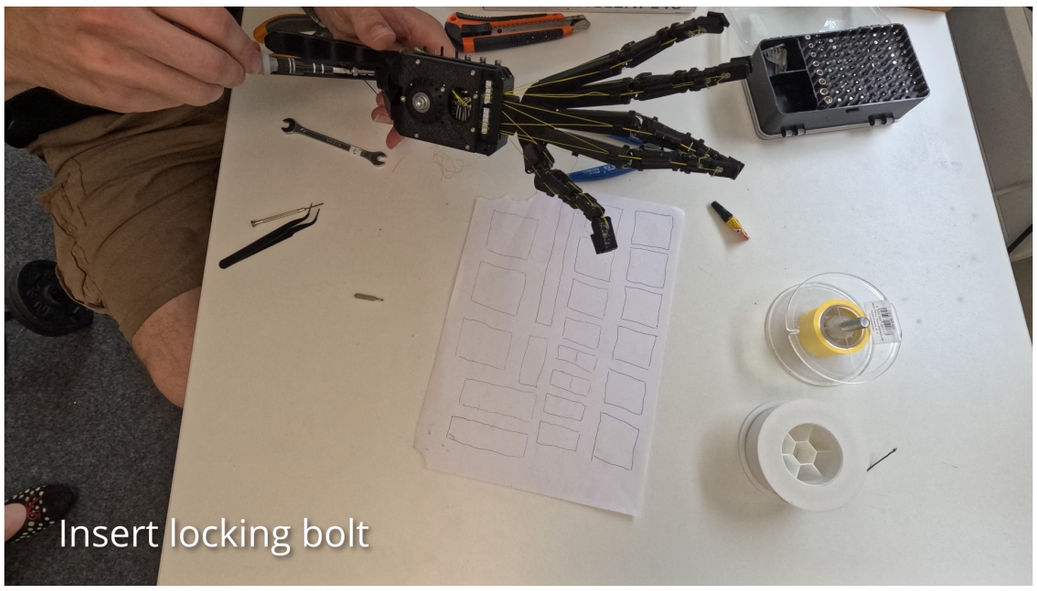

Figure 3.2e: ..

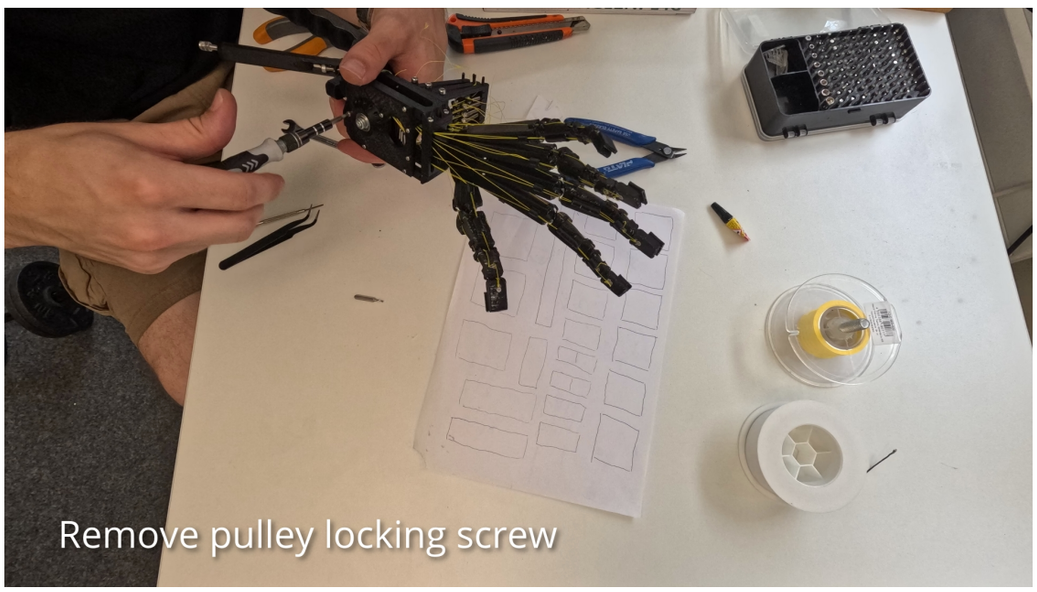

Figure 3.2f: ..

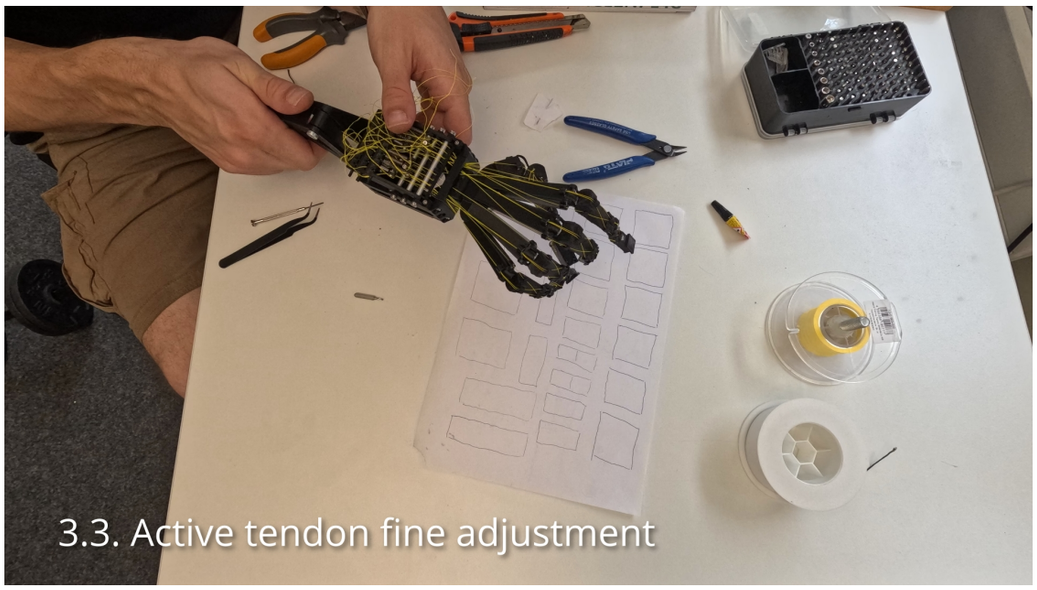

Figure 3.3: ..

Figure 3.3a: ..

4 Testing

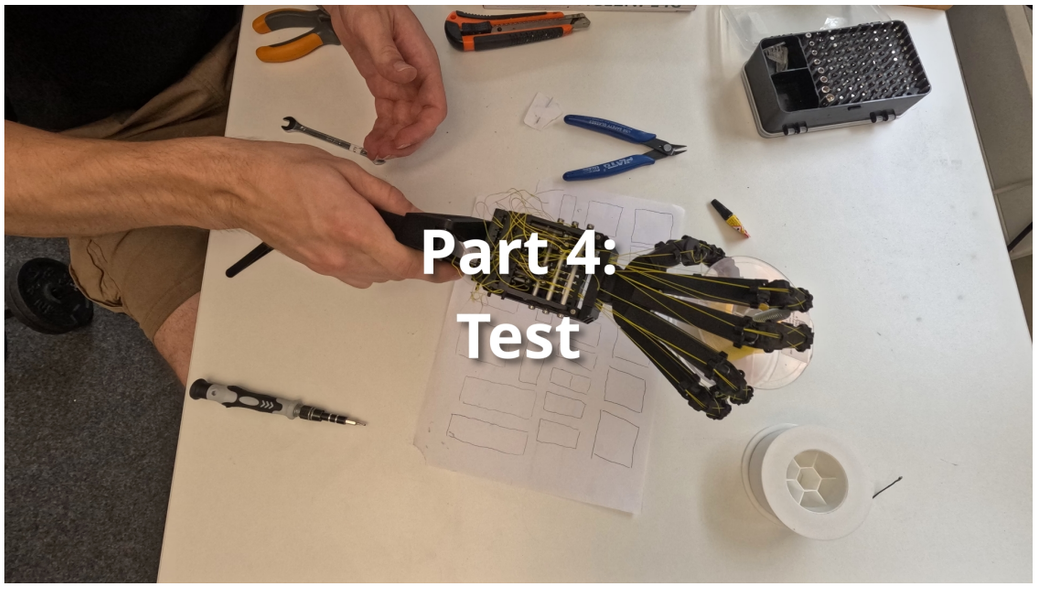

Figure 4: ..

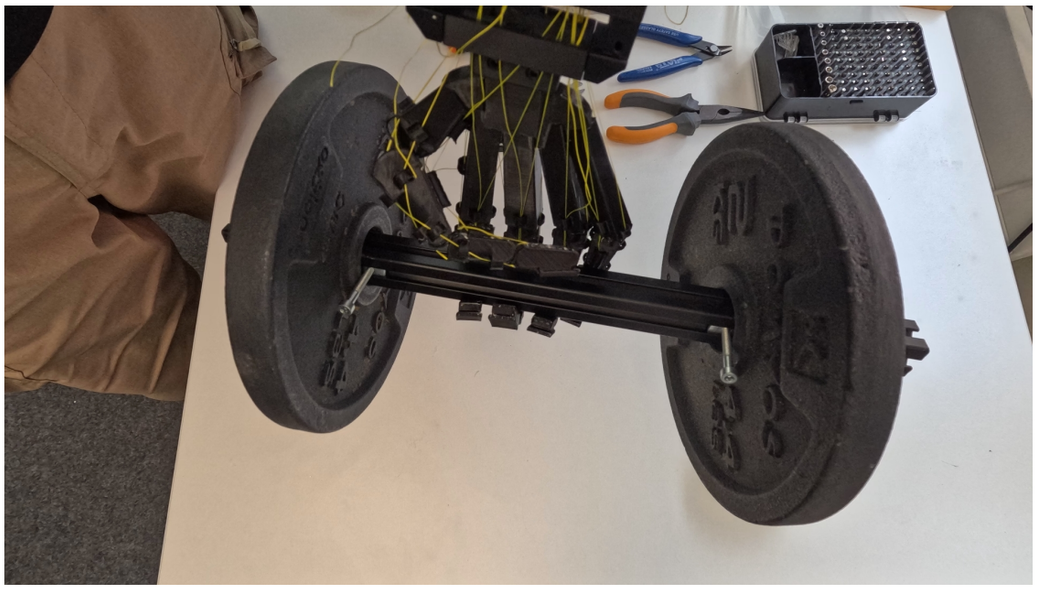

Figure 4a: ..

Troubleshooting