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PLEXUS Hand: Lightweight Four-Motor Prosthetic Hand Enabling Precision–Lateral Dexterous Manipulation

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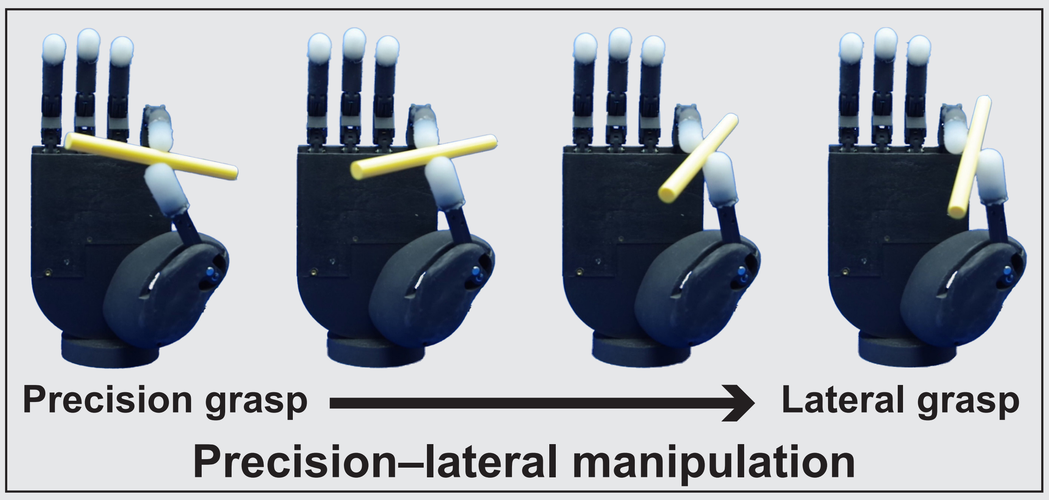
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1.Motivation

- Daily activities require rotating objects between different grasps
- Current prosthetic hands only achieve static grasp postures
- In-hand manipulation requires many motors (heavy) or external mechanisms (vulnerable)

Challenge

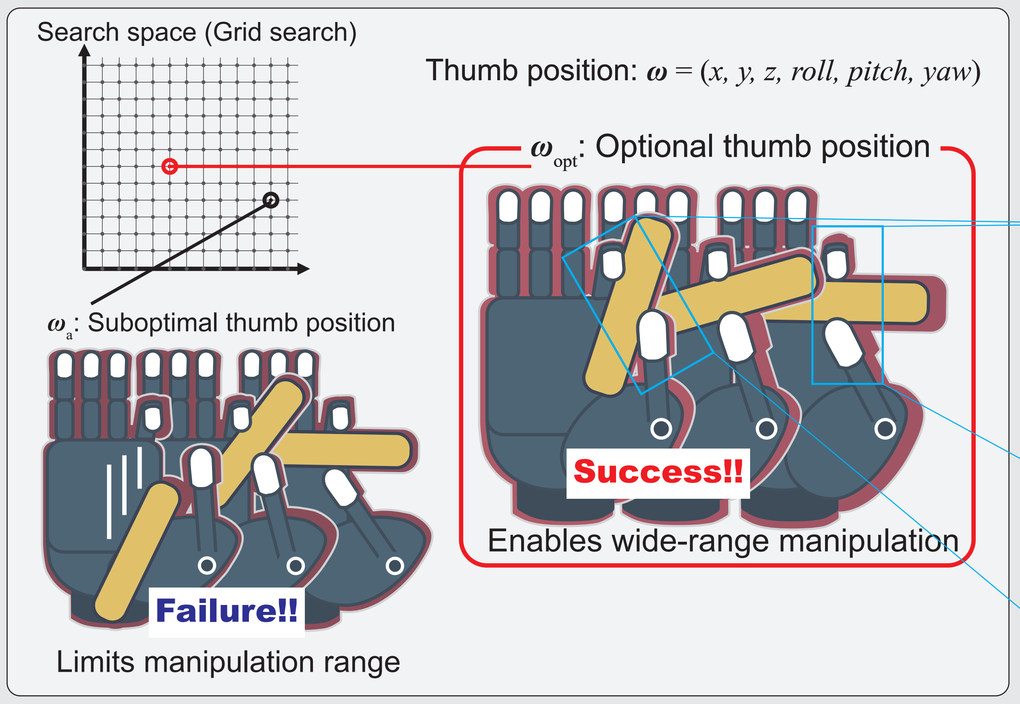
Can we enable precision–lateral manipulation while maintaining a lightweight (<500g) design with internal motors?



2. Our Approach

- Single-axis thumb design inspired by human thumb movement
- Computational optimization of thumb CM joint rotation axis
- 4-motor design (one shared for ring-little fingers)

II. **Finding optimal thumb position for maximum manipulation range** W



Optimization approach

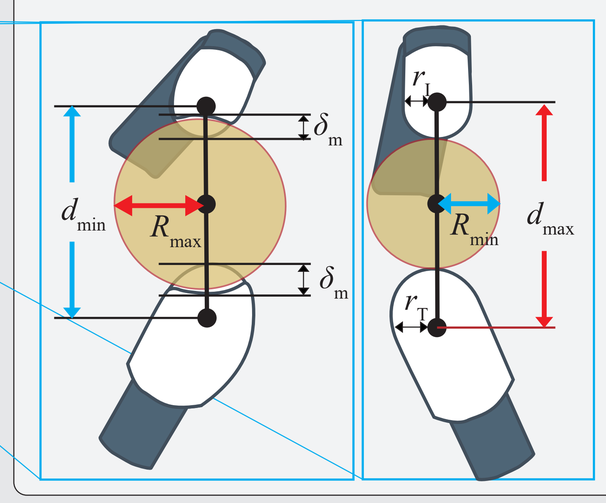
Goal: Maximize precision–lateral manipulation width range

I. Calculate manipulation range $W(\omega)$ for each candidate thumb position

II. Find thumb position with maximum range: $\omega_{opt} = \arg\max |W(\omega)|$

How to calculate manipulation range $W(\omega)$

1. Fix index finger at position i



2. Calculate range at position i

$$W_i(\omega) = [2R_{min}, 2R_{max}]$$
$$= [d_{max}(i, \omega) - (r_T + r_I), d_{min}(i, \omega) - (r_T + r_I) + 2\delta_m]$$

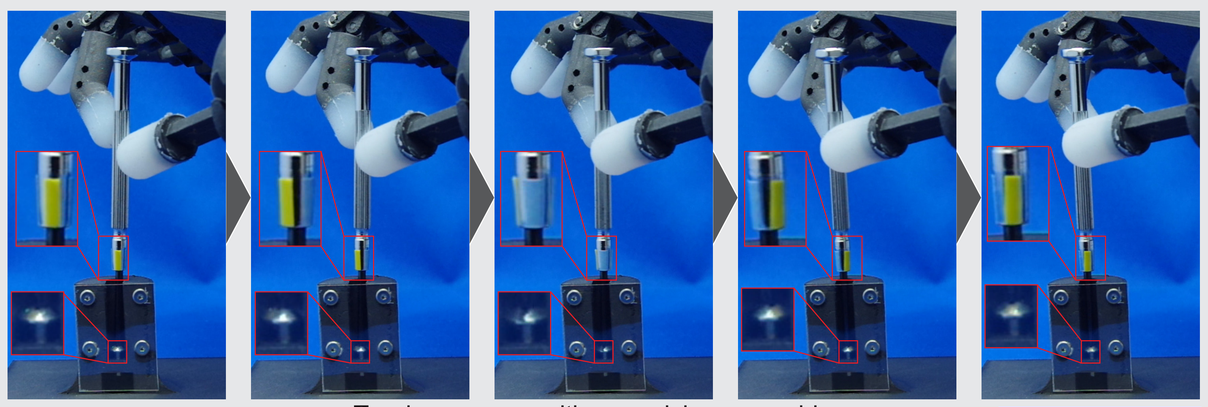
3. Find intersection of all possible index positions I

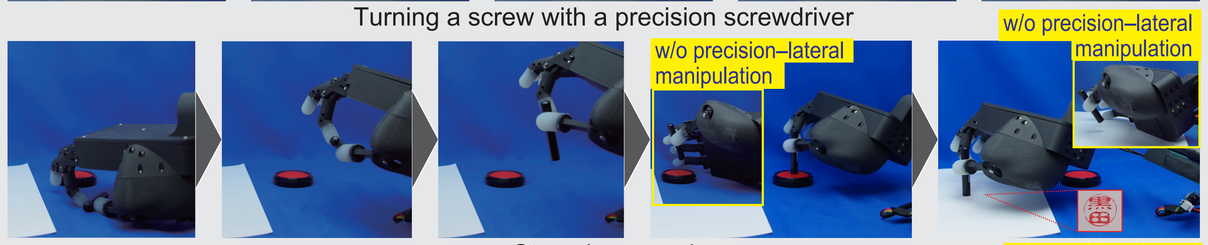
$$W(\omega) = \bigcap_{i \in I} W_i(\omega)$$

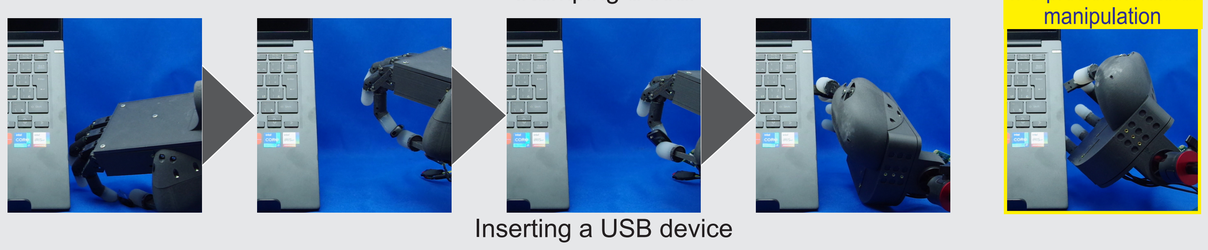
3. Results

- Weight: Only 311 g with all motors inside
- Manipulation: 90–100% success rates with 5–30 mm objects (cylinders and prisms)
- Real-world tasks: Successfully performed seal stamping, USB insertion, and screwdriver operation









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