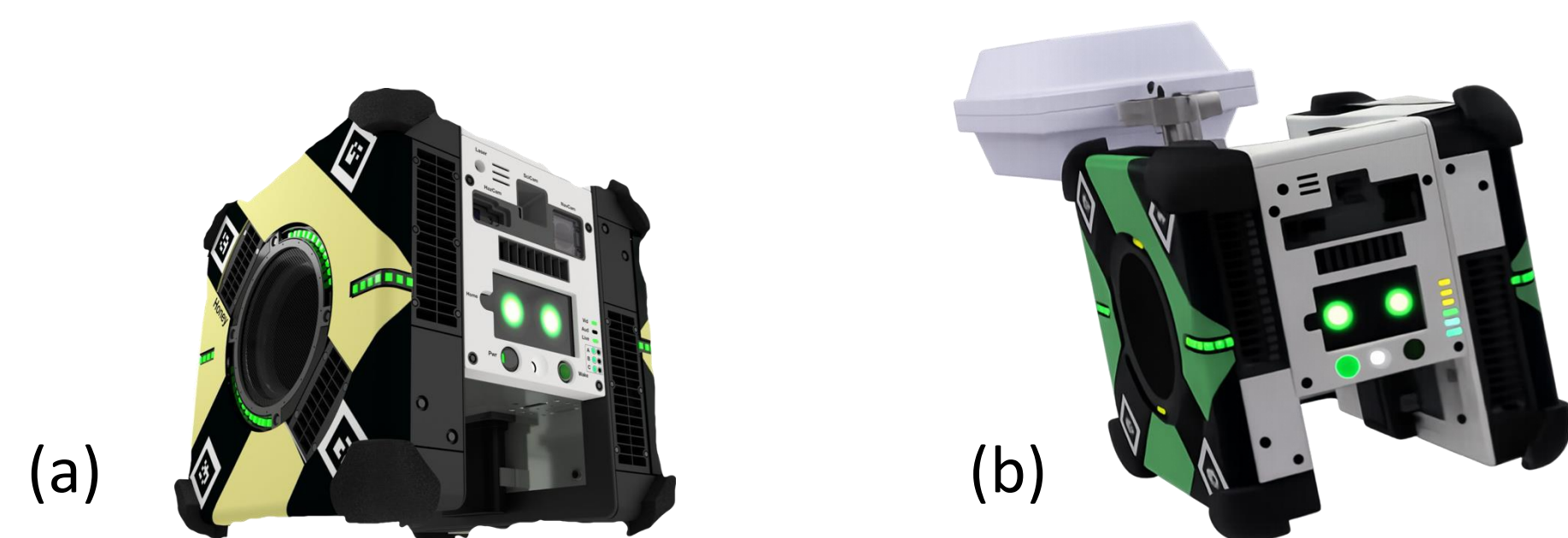


Introduction

Astrobee is a free-flying robot aboard the International Space Station (ISS) that supports autonomous on-orbit operations such as:

1. Routine station maintenance and inspection
2. Payload transportation between modules
3. Docking at a charging or data transfer station
4. Perching onto handrails for stable operations

Astrobee's current perching arm uses a 1-DOF compliant claw gripper, **but as space tasks grow in complexity, future free-flyers require more dexterous end-effectors.**



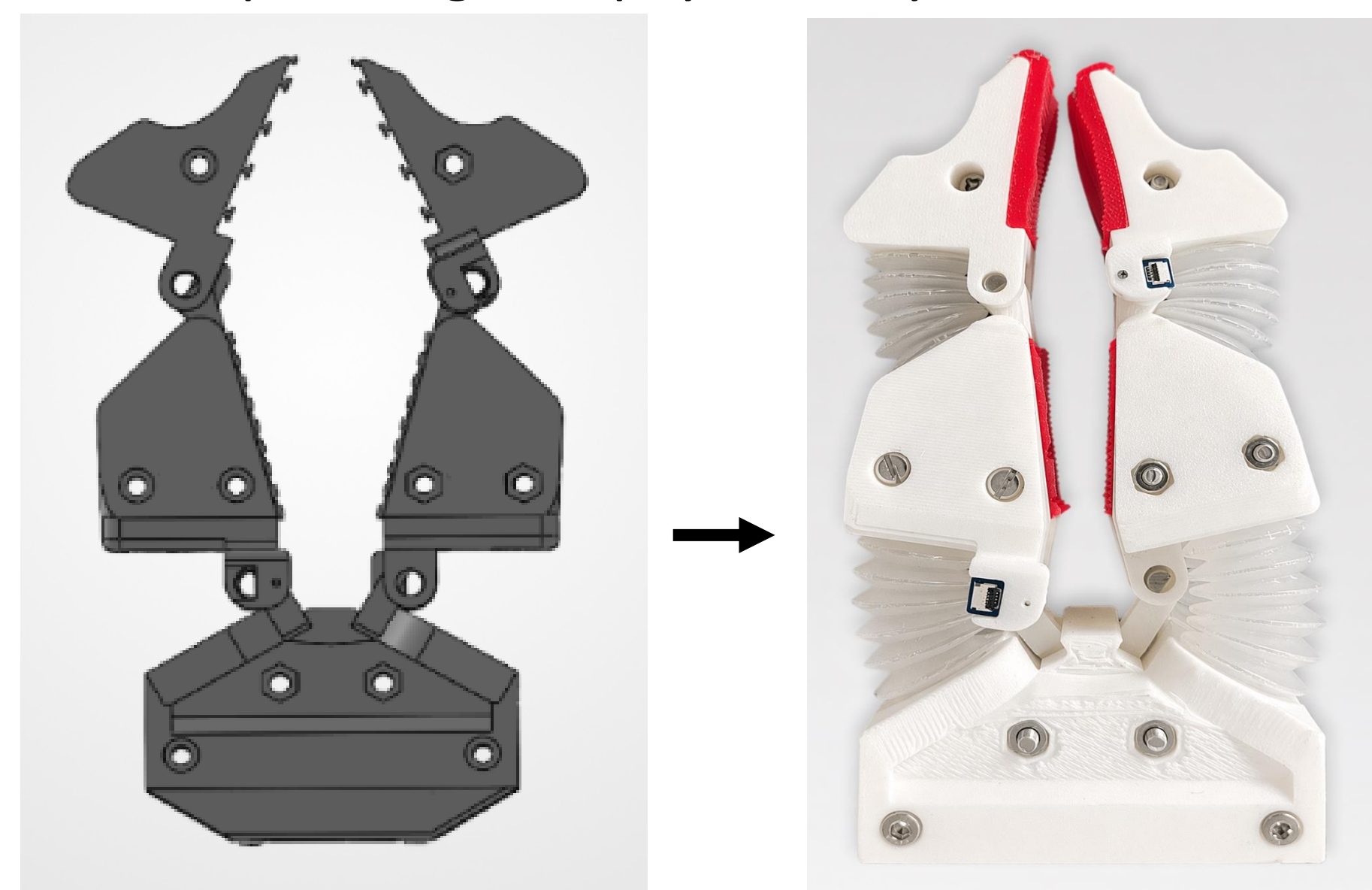
(a) Astrobee free-flying robot
 (b) Astrobee with attached end-effector payload

DexCoHand

The dexterous and compliant hand (DexCoHand) is 2F-6DOF gripper designed for dexterous in-hand manipulation tasks. It includes:

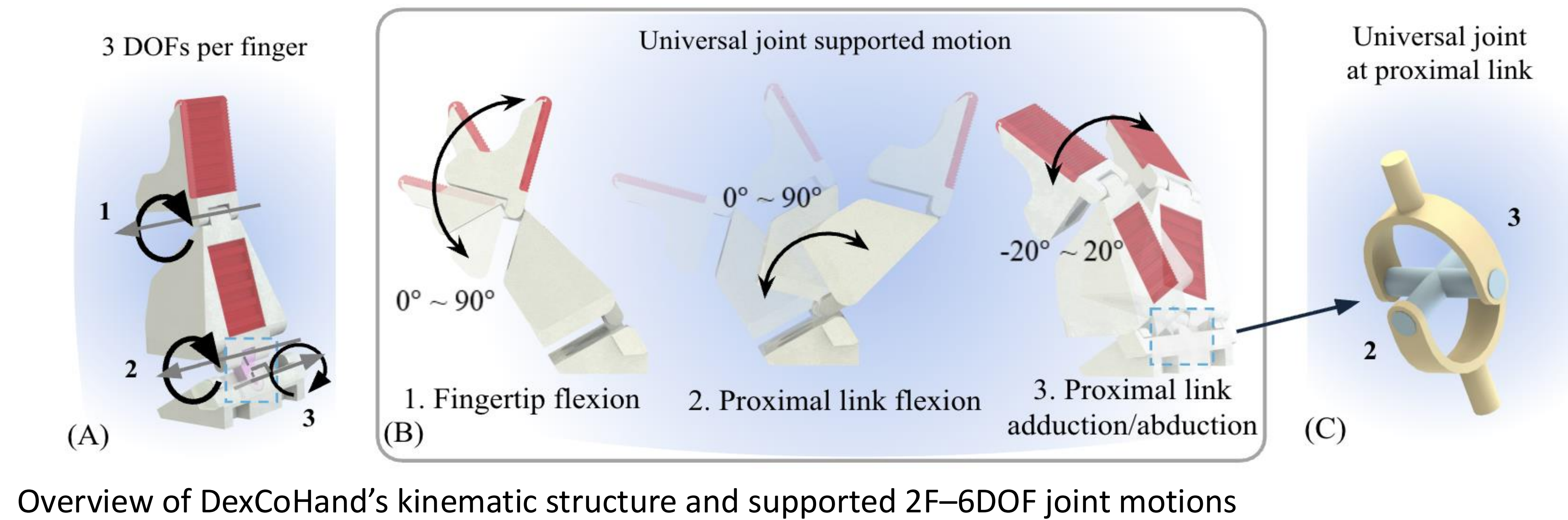
- Layered silicone fingertips for conformal contact across varied geometries
- Soft hydraulic actuation for compliant and robust contact
- 3 DOF per finger for in-hand object reorientation without regrasping

With a custom adapter, DexCoHand can attach to Astrobee's perching arm payload bay.

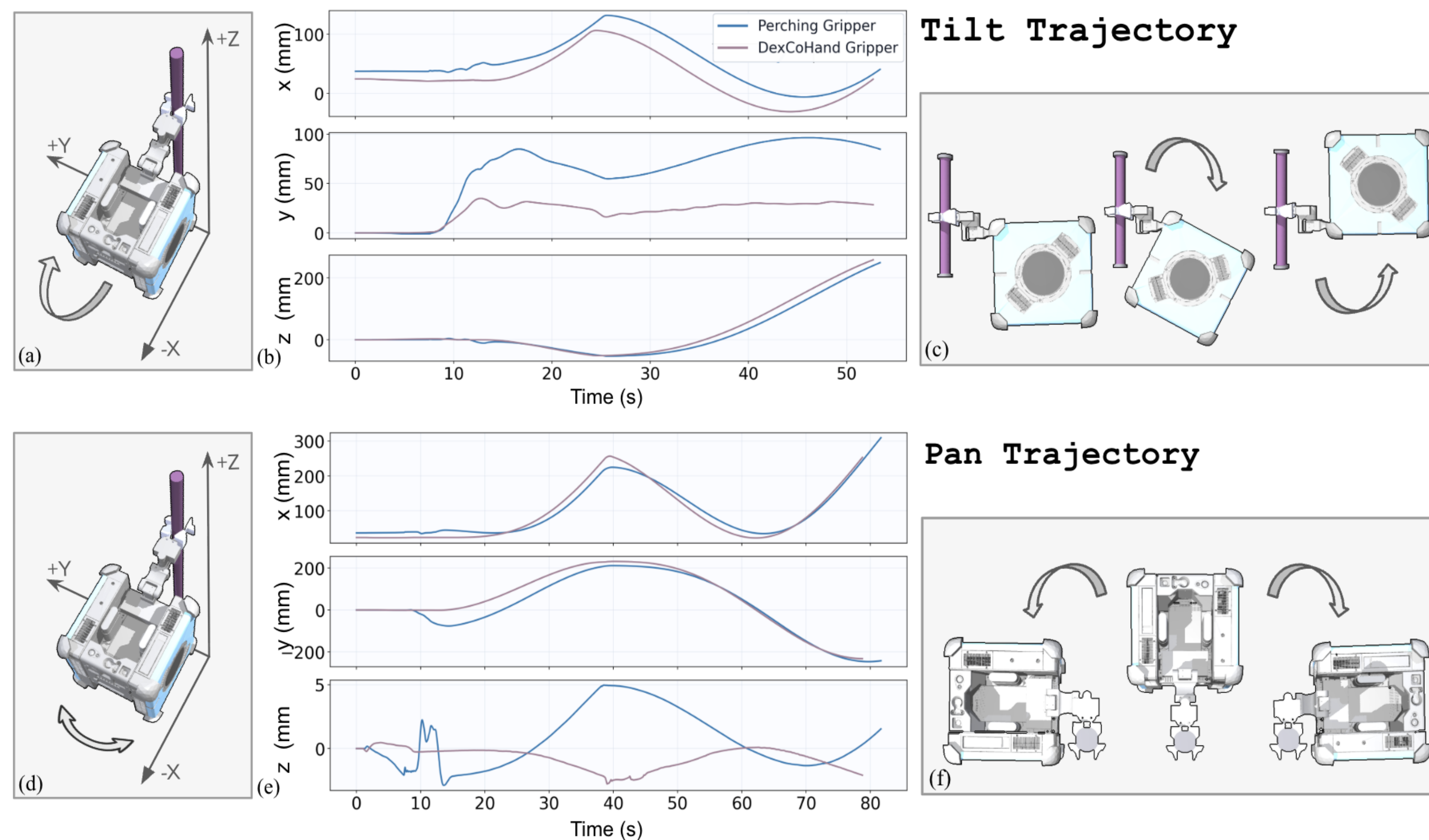


CAD Design Assembled Prototype

Gripper Kinematics



Simulation Results



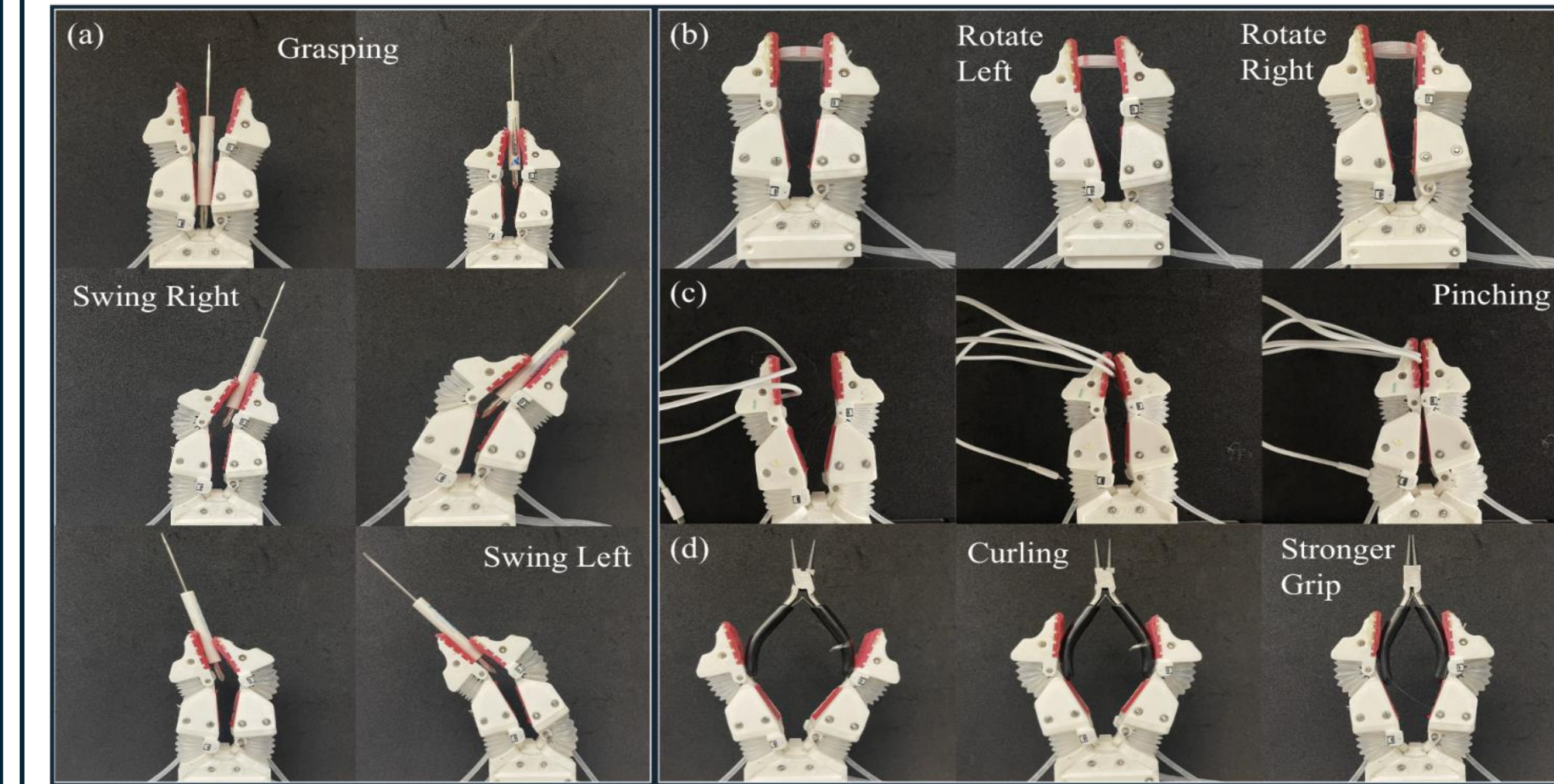
Simulation Setup:

We evaluate two Astrobee configurations in MuJoCo: the baseline 1-DOF compliant claw gripper and the proposed DexCoHand end-effector. Each configuration performs Astrobee's standard handrail perching sequence, consisting of approach, perch, and a subsequent pan or tilt maneuver.

Key Results:

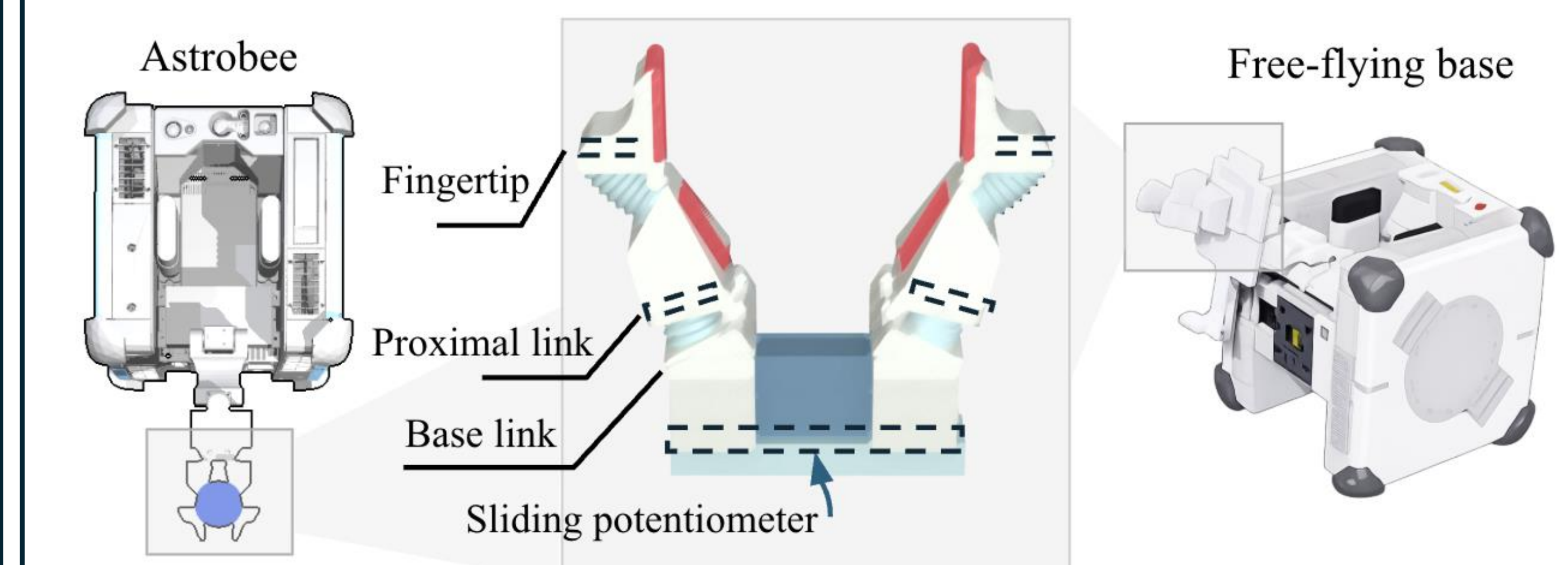
- During tilt, the baseline gripper reaches approximately 80 mm lateral deviation, while DexCoHand reduces this deviation to about 20 mm.
- During pan, DexCoHand remains near 0 to -2 mm deviation, while the baseline gripper varies from approximately -2 to 4 mm.

Manipulation Capabilities



Hardware experiments demonstrating dexterous manipulation capabilities achieved by DexCoHand:

- a. Grasping and controlled pivoting
- b. Object reorientation without regrasping
- c. Precision pinch of small objects
- d. Caging around unstable objects



System overview of DexCoHand mounted on Astrobee's perching arm as a 2F-6DOF compliant end-effector payload.

Conclusion

- DexCoHand preserves nominal pan/tilt perching behavior while reducing unintended cross-axis base motion.
- Added finger DOF and soft hydraulic compliance extend Astrobee from grasping and perching toward dexterous microgravity manipulation.
- Future work will extend this framework to full in-hand manipulation tasks under closed-loop control in simulation.

Acknowledgement

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