COLUMBIA ENGINEERING
The Fu Foundation School of Engineering and Applied Science

Versatile Manipulation for Assistive Free-Flyers

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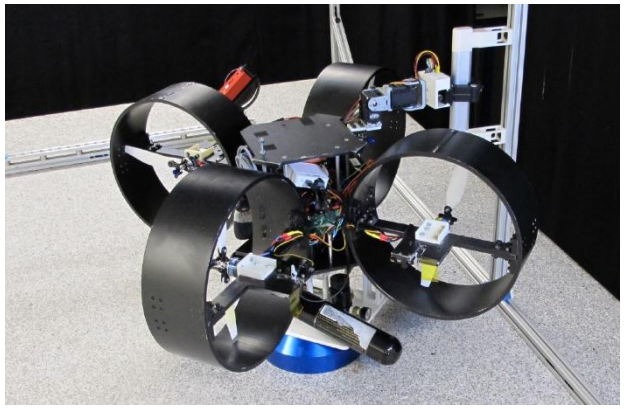
Research Objectives

- Main goal: endow AFFs with the ability to interact with the environment through manipulation.
- Innovations: **compact, versatile end-effectors along with new supervisory control methods** enabling robust execution of multiple tasks.
- State of the art: AFFs can navigate, but do perform tasks requiring manipulation.
  - Start TRL: 2. Concepts exist, but versatile manipulation has not been demonstrated.
  - End TRL: 4/5. Prototype tested in realistic conditions.



Astrobee AFF prototype perching with end-effector developed at Columbia (image courtesy of NASA Ames IRG)

Approach

- Use tendon-driven multiDOF joints and soft synergies for compact kinematic chains.
- Ensure suitability for set of tasks through simulation-based design optimization.
- Regulate environment contact forces through built-in mechanical compliance, allowing button pushing or peg-in-hole insertion without complex sensing.
- Use supervisory teleoperation for ground crew to provide high-level task goal, modeling and leveraging built-in robustness to execution errors.

Potential Impact

- Versatile end-effectors can enable many tasks for AFFs with limited payload.
- Supervisory control for versatile manipulation allows ground-based teleoperation.
- Handling variability in the environment increases task success rate and robustness to pose errors.
- Manipulation can broaden the applicability of AFFs to tasks that include object retrieval (e.g. tools or food items), housekeeping tasks (e.g. filter change), switchboard operation, etc.