

MOTIVATION

Infrastructure inspection, maintenance, and emergency response require contact-rich aerial interaction with complex maneuvers.

Existing UAVs fall short to simultaneously achieve:

- Arbitrary-orientation flight
- Physical interaction (force application)
- Robustness to disturbances

Goal: Enable drones to act as a flying human hand.

THREE CAPABILITIES (MMR)

MANEUVERABILITY
Full 6-DoF motion independent of orientation

MANIPULATION
Apply forces and torques in arbitrary directions

RESILIENCY
Reject disturbances and external perturbations from any direction

THE THREE ENABLERS

Achieving MMR requires all three enablers:

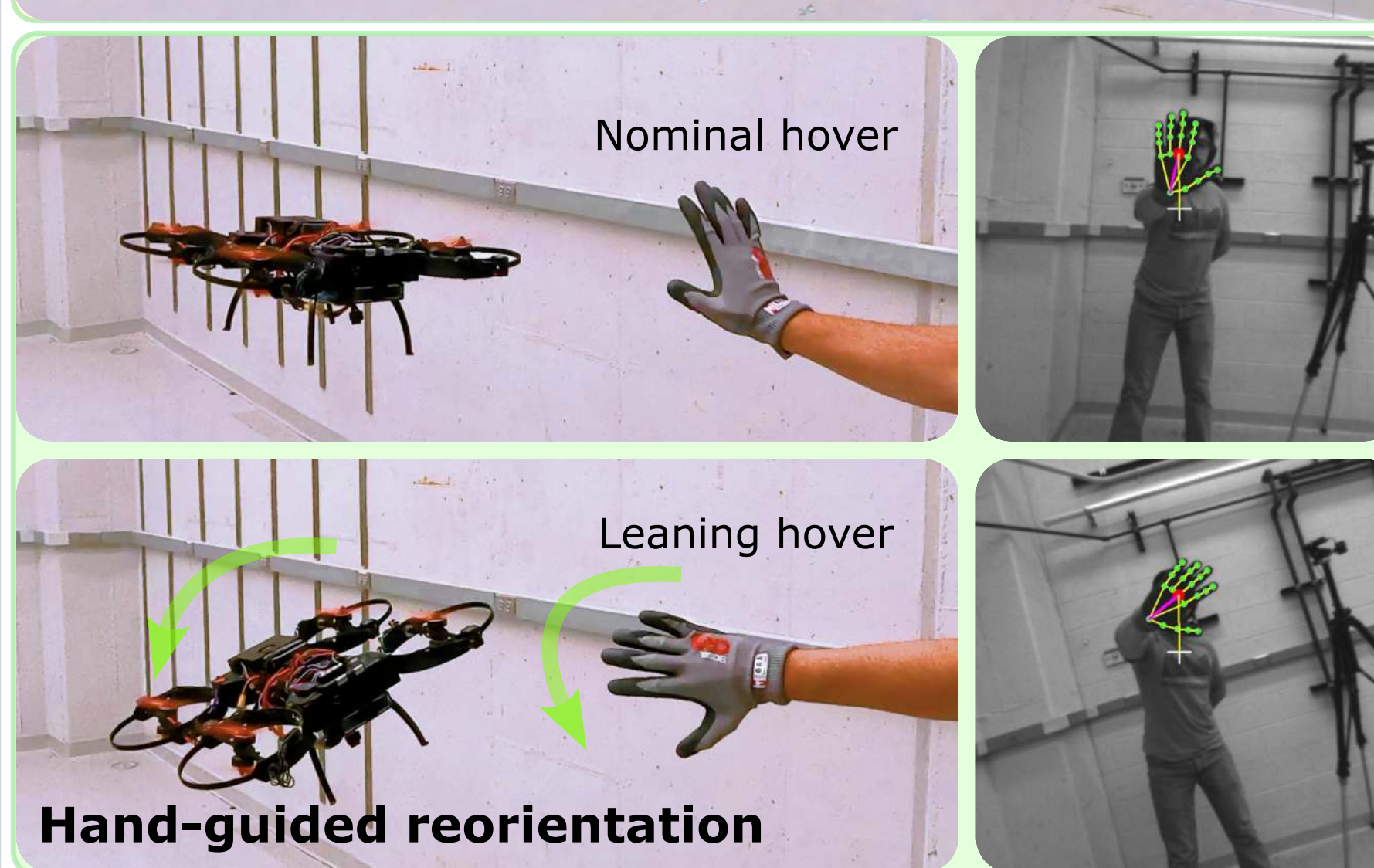
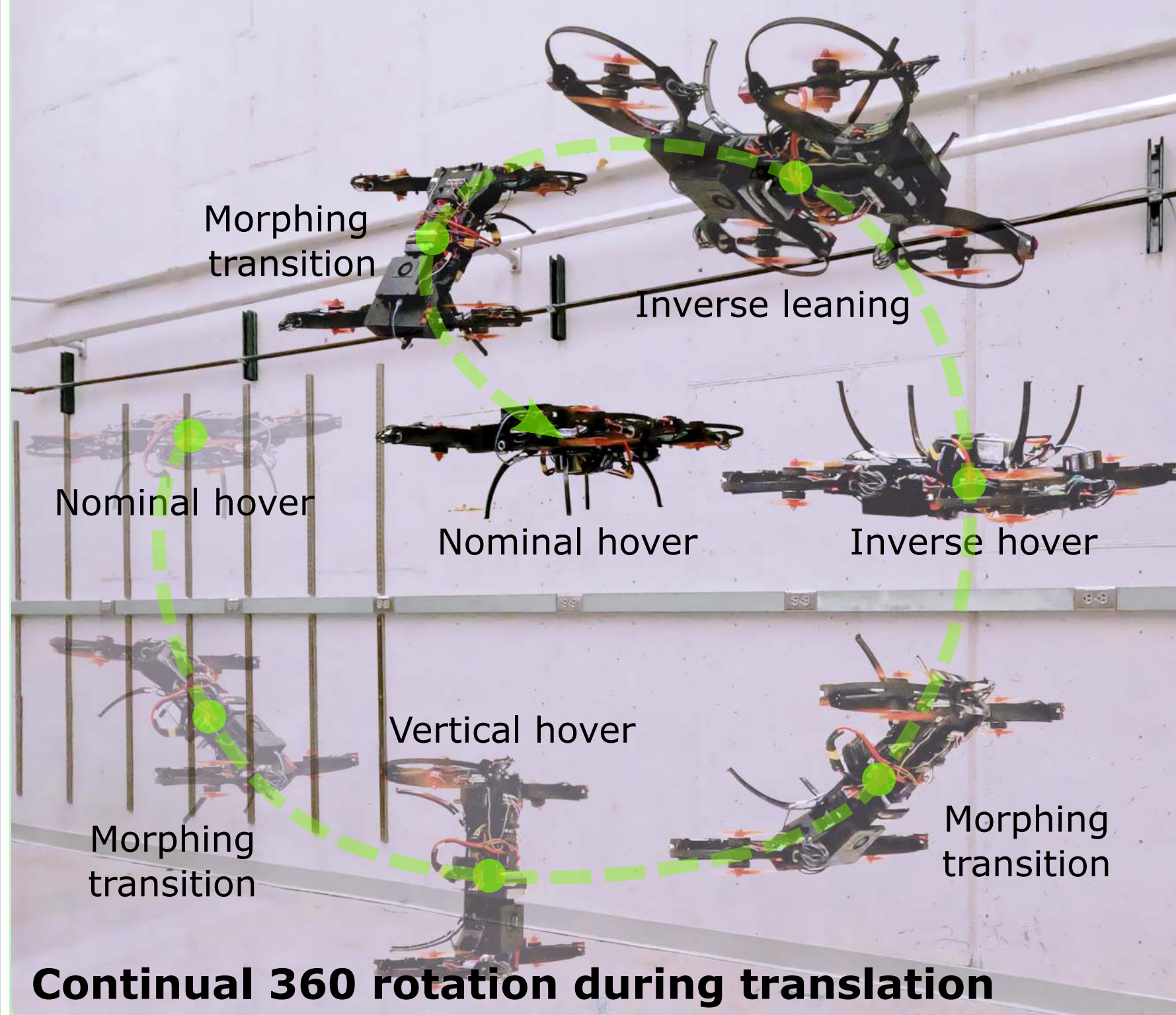
- MAX THRUST VECTORING**
Generate maximum thrust in any direction
- GLOBAL STABILITY**
Stable across all orientations and positions
- LOW-COMPLEXITY COMPACT DESIGN**
Inherit compact quadrotor footprint and technological know-how

KEY SPECIFICATIONS

Mass (ready-to-fly)	4.56 kg
Max. Thrust (any dir.)	110 N
Hover Time	5-10 min
Actuation DoF	12 (3 per rotor)
State Estimation	VIO + IMU

MorphQuad: OVERVIEW

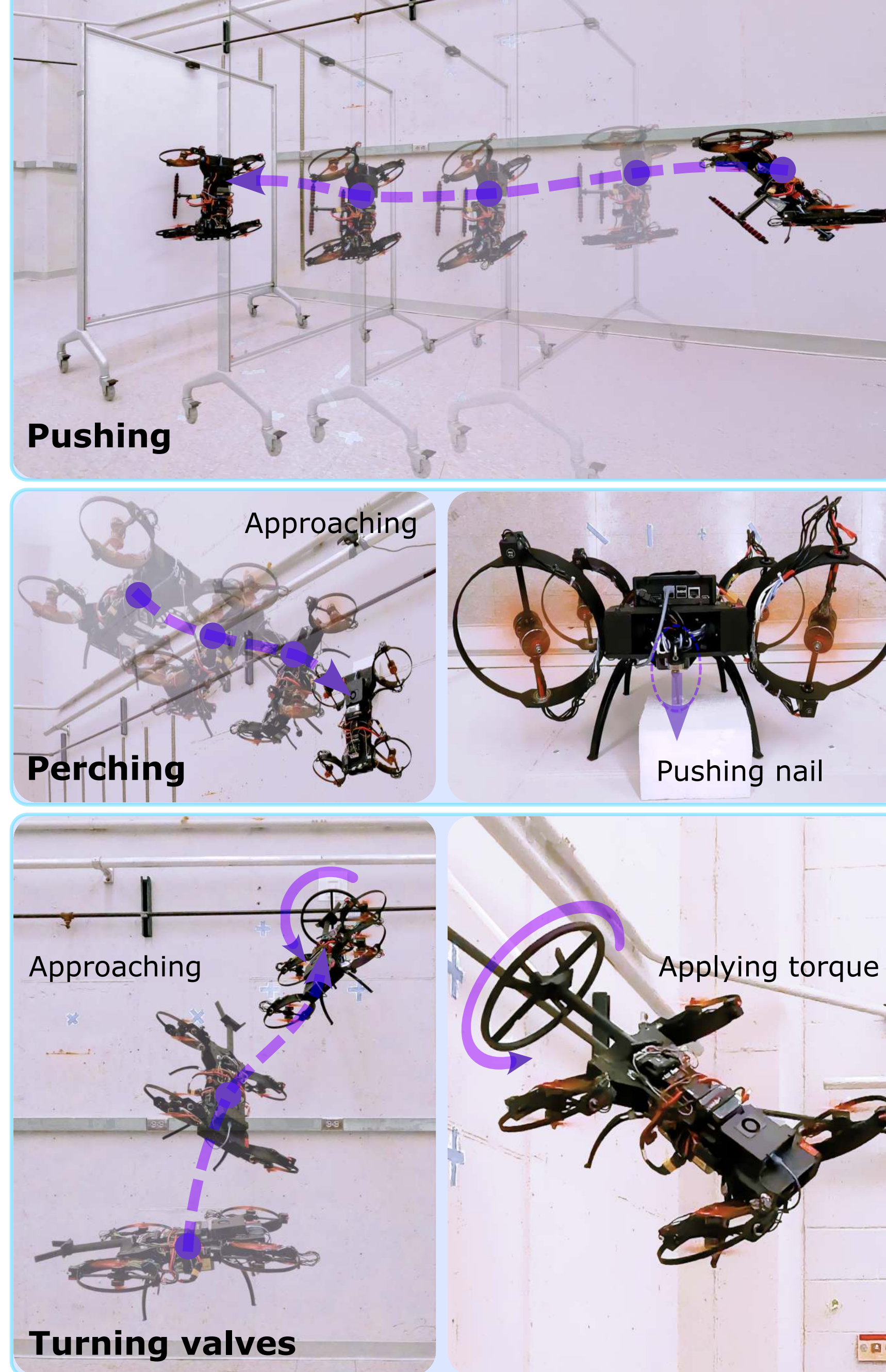
(A) Maneuverability



(C) Resiliency



(B) Manipulation

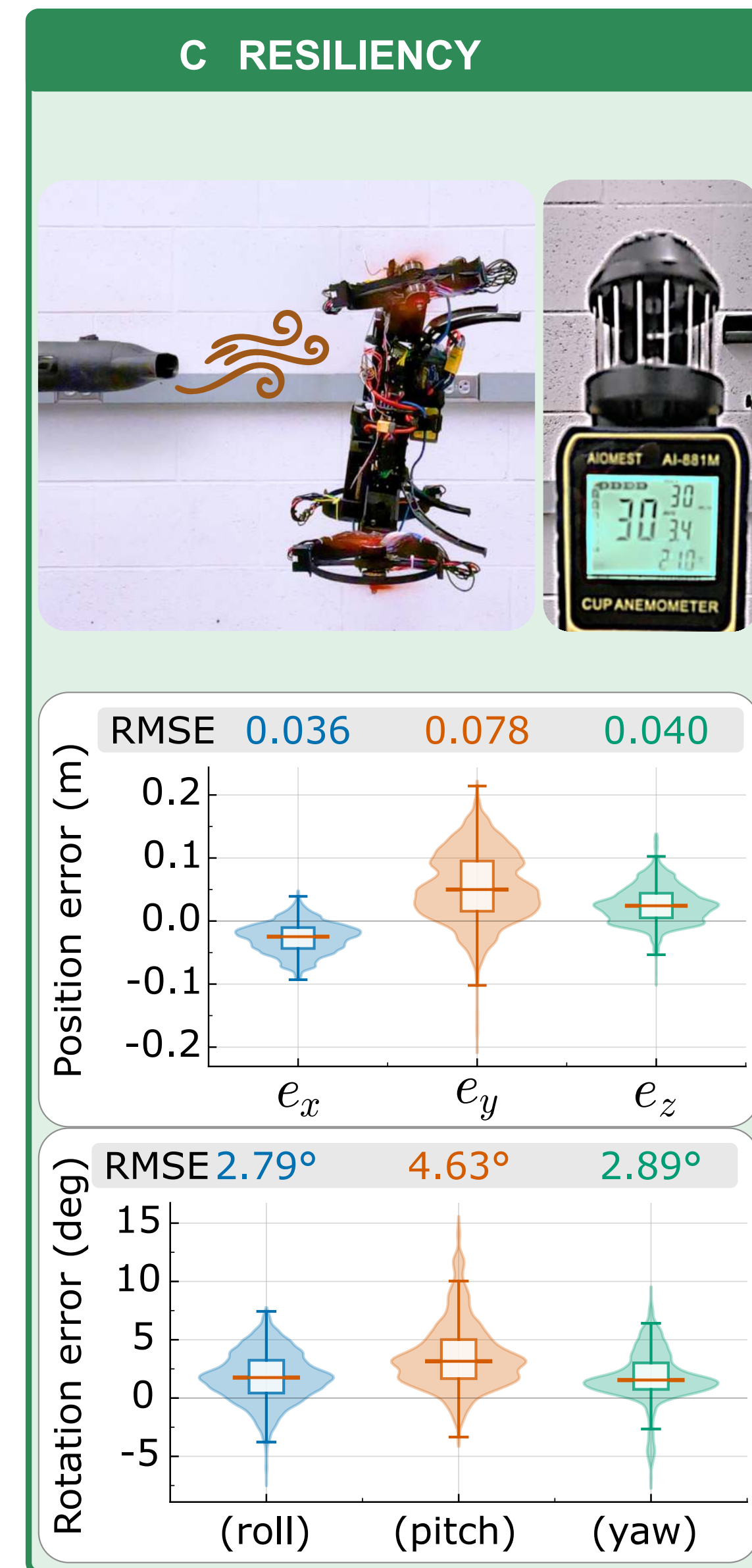
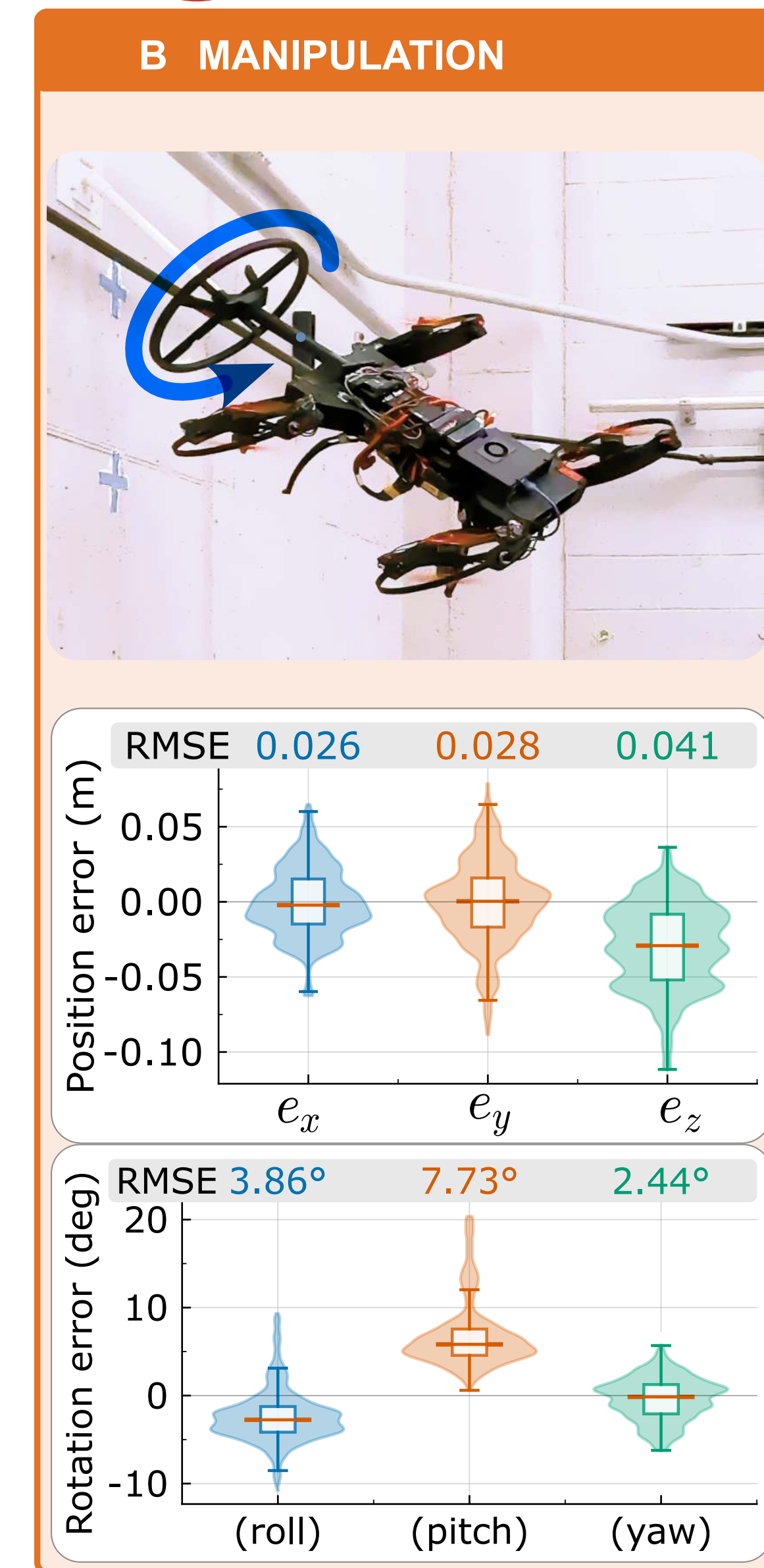
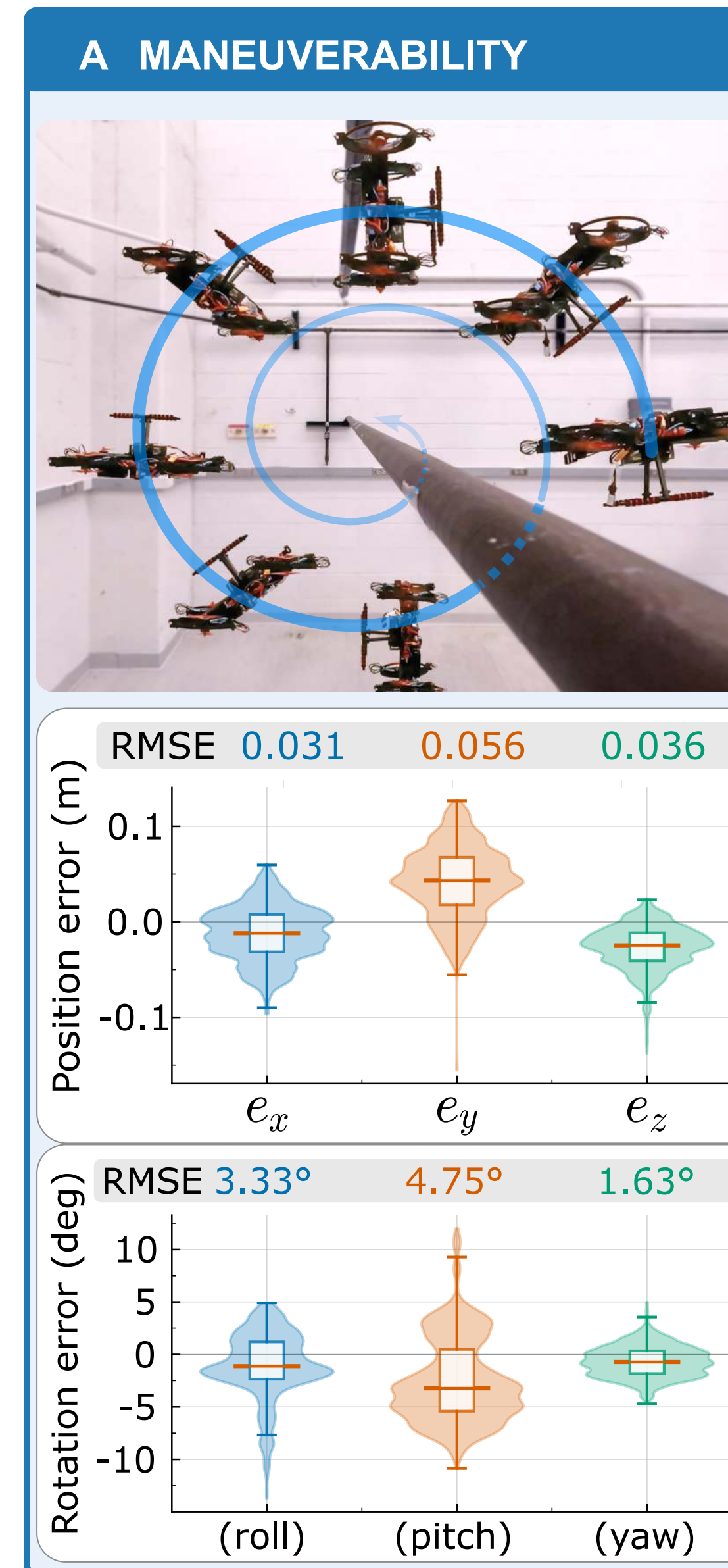


EXPERIMENTAL RESULTS

Fully onboard autonomy

No motion capture or GPS required

Real-world experiments



TAKEAWAY

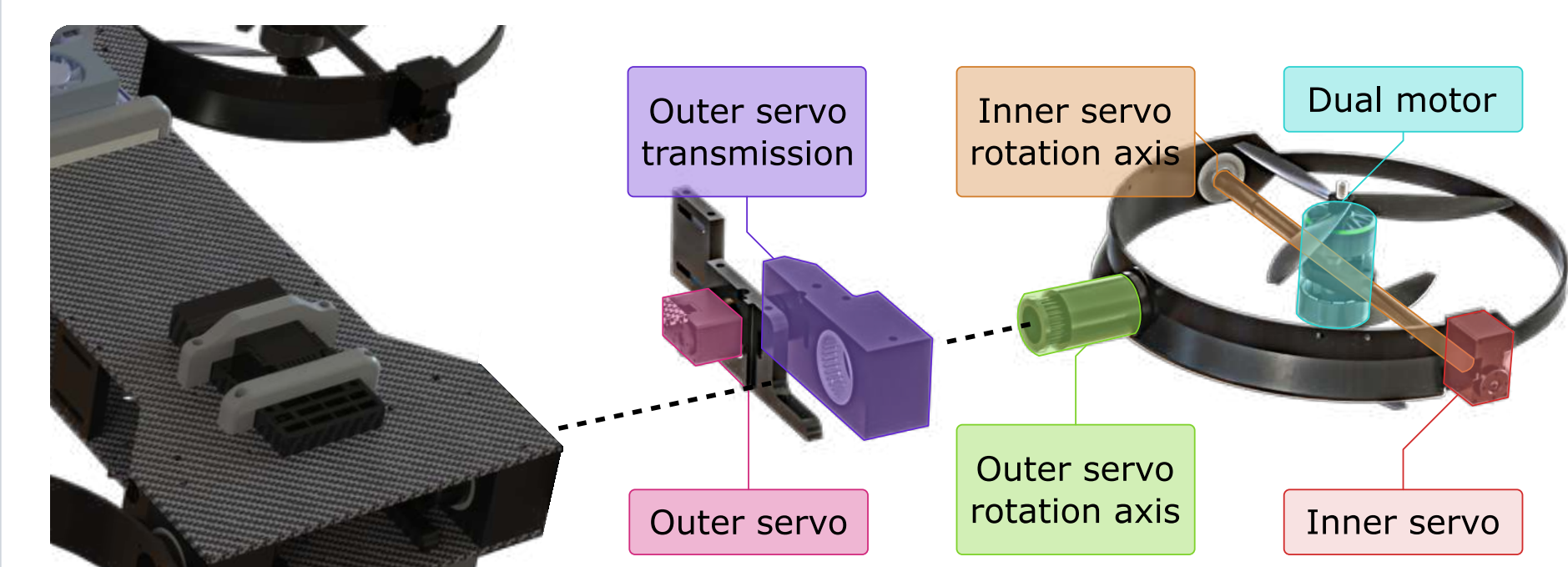
A **quadrotor** that **maneuvers, manipulates, and endures disturbances**: Navigates tight spaces. Turns valves. Perches. Points and tracks. Pushes and pulls. Resilient to winds, physical displacements, and rotor failures. **At any orientation.**

Scan for videos

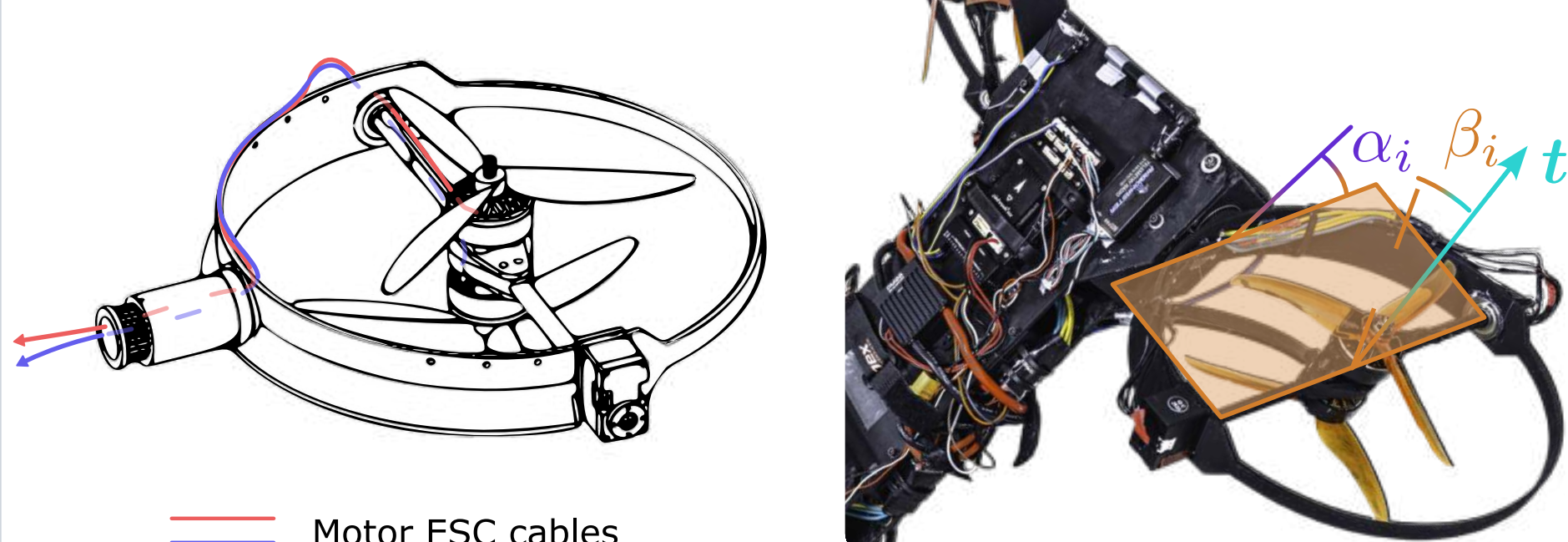


SYSTEM ARCHITECTURE

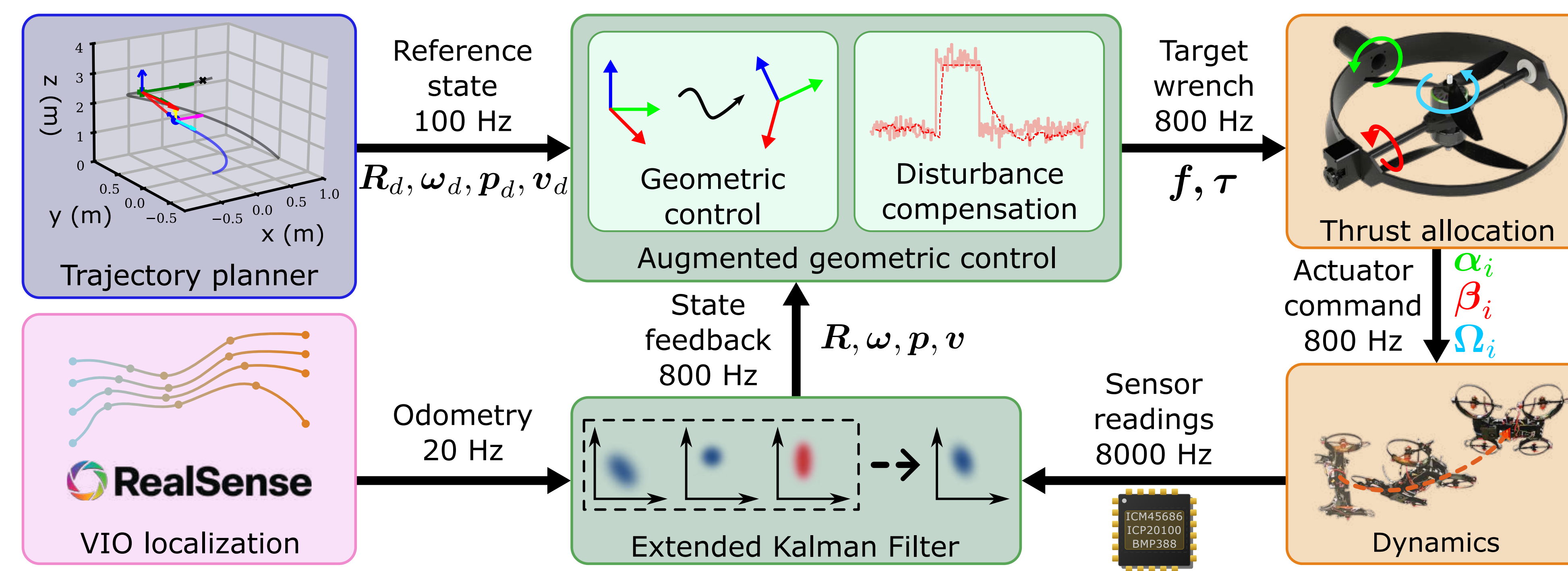
INDEPENDENT ROTOR ARTICULATION



CO-AXIAL COUNTER-ROTATING



AUTONOMY & CONTROL PIPELINE



HARDWARE COMPONENTS

