

Six-DoF Hand-Based Teleoperation for Omnidirectional Aerial Robots

Jinjie LI[†], Jiaxuan LI[†], Haokun Liu, Kotaro Kaneko, Liming Shu, Moju Zhao



LI, Jinjie

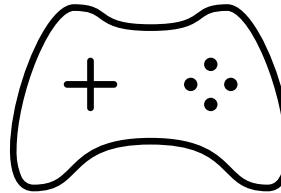
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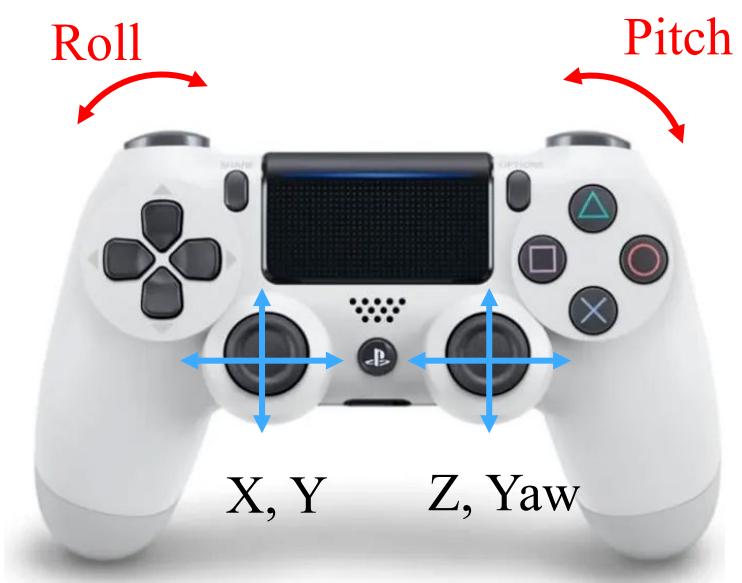
LI, Jiaxuan

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Introduction – Omnidirectional Teleoperation



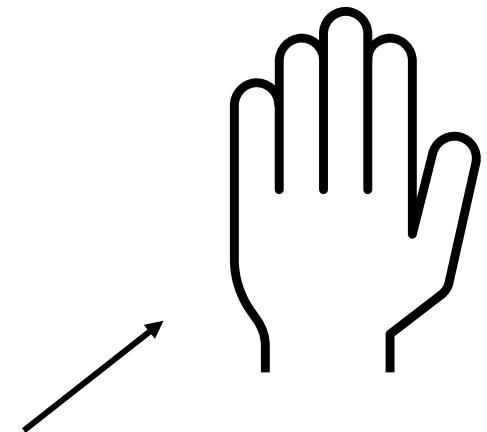
Demos



$$\mathbb{R}^2 \times \mathbb{R}^2 \times \mathbb{R}^2 \cong \mathbb{R}^6$$

Not Equal !

$$SE(3) \cong \mathbb{R}^3 \times SO(3)$$



Introduction – Omnidirectional Teleoperation

Haptic Devices



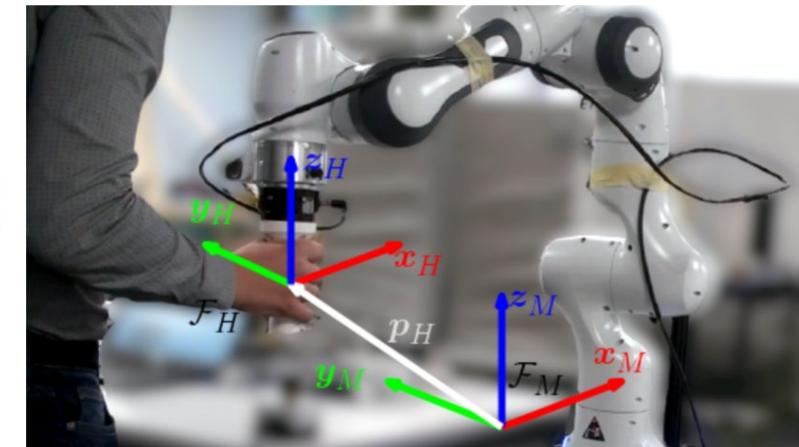
J. Mellet, M. Tognon, et al., arXiv, 2024



Lambda



Space Joystick

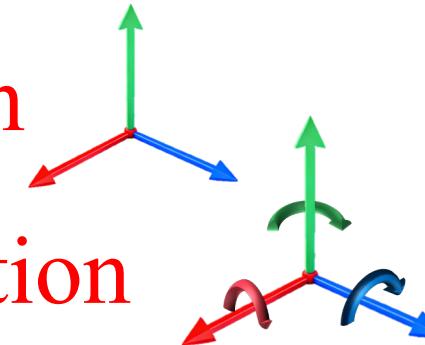


M. Allenspach, M. Tognon, et al., ICRA, 2022



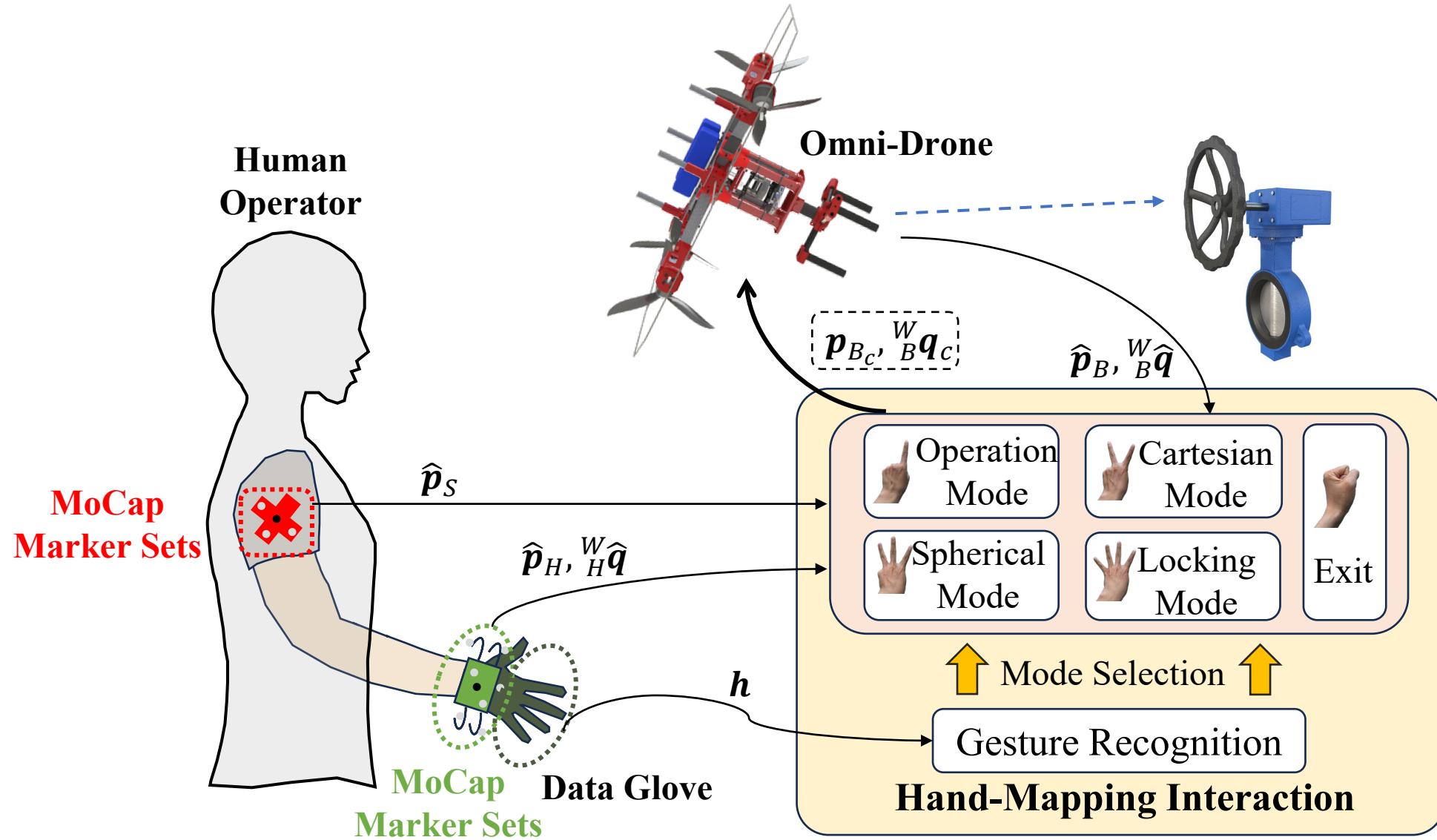
The fingers are constrained.

- ✓ Hand **position**
- ✓ Hand **orientation**
- ☐ Hand **gesture**



Finger freedom matters.

Omnidirectional Aerial Teleoperation

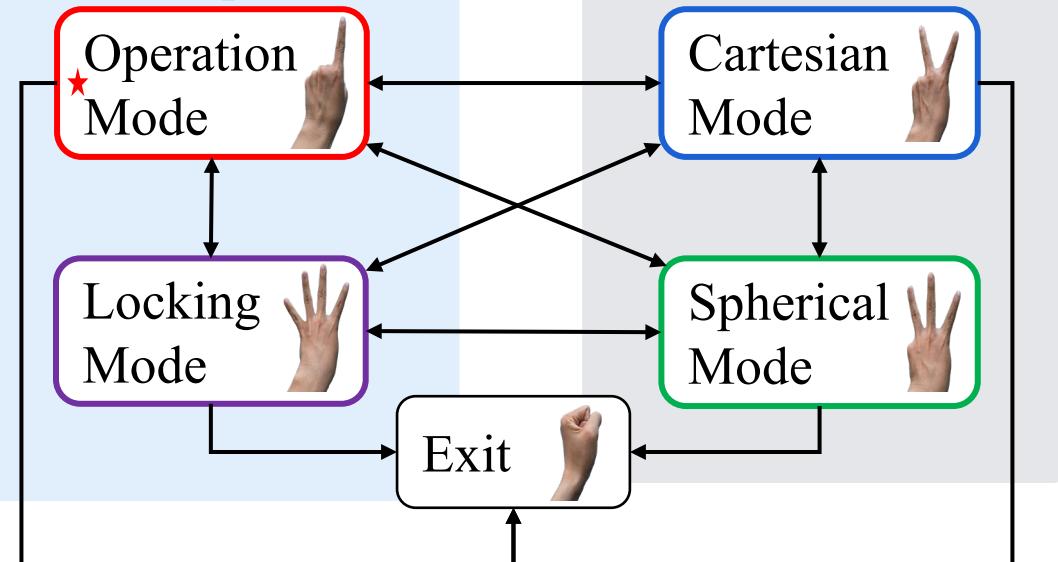


Hand-Based Interaction

$$\mathbf{p}_{B_c} = \hat{\mathbf{p}}_B(t_0) + \mathbf{k} \cdot (\hat{\mathbf{p}}_H(t) - \hat{\mathbf{p}}_H(t_0)),$$

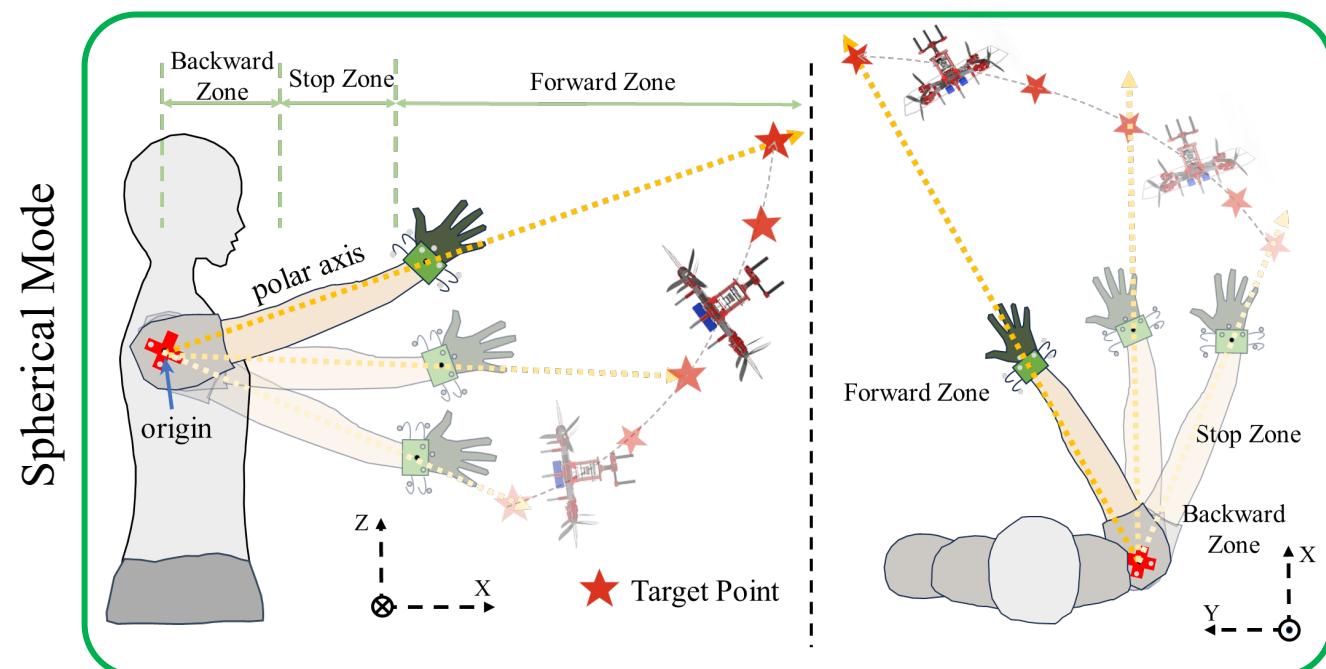
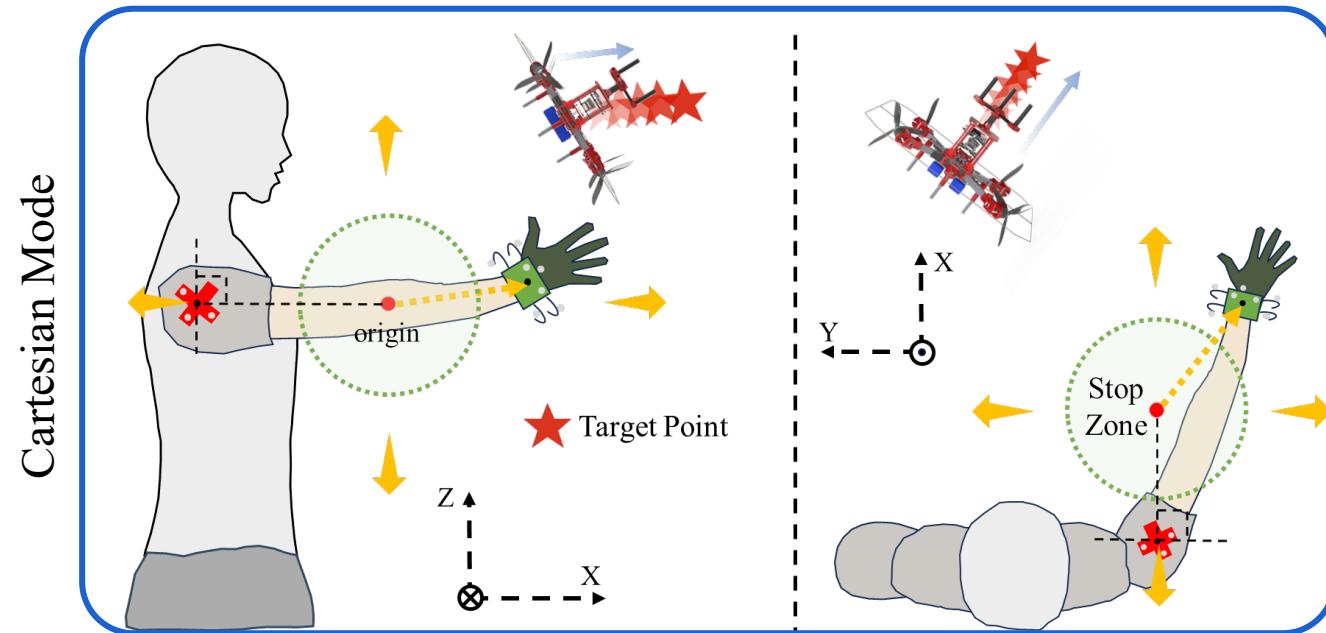
$${}^W_B \mathbf{q}_c = {}^W_H \hat{\mathbf{q}}.$$

Precise Operation

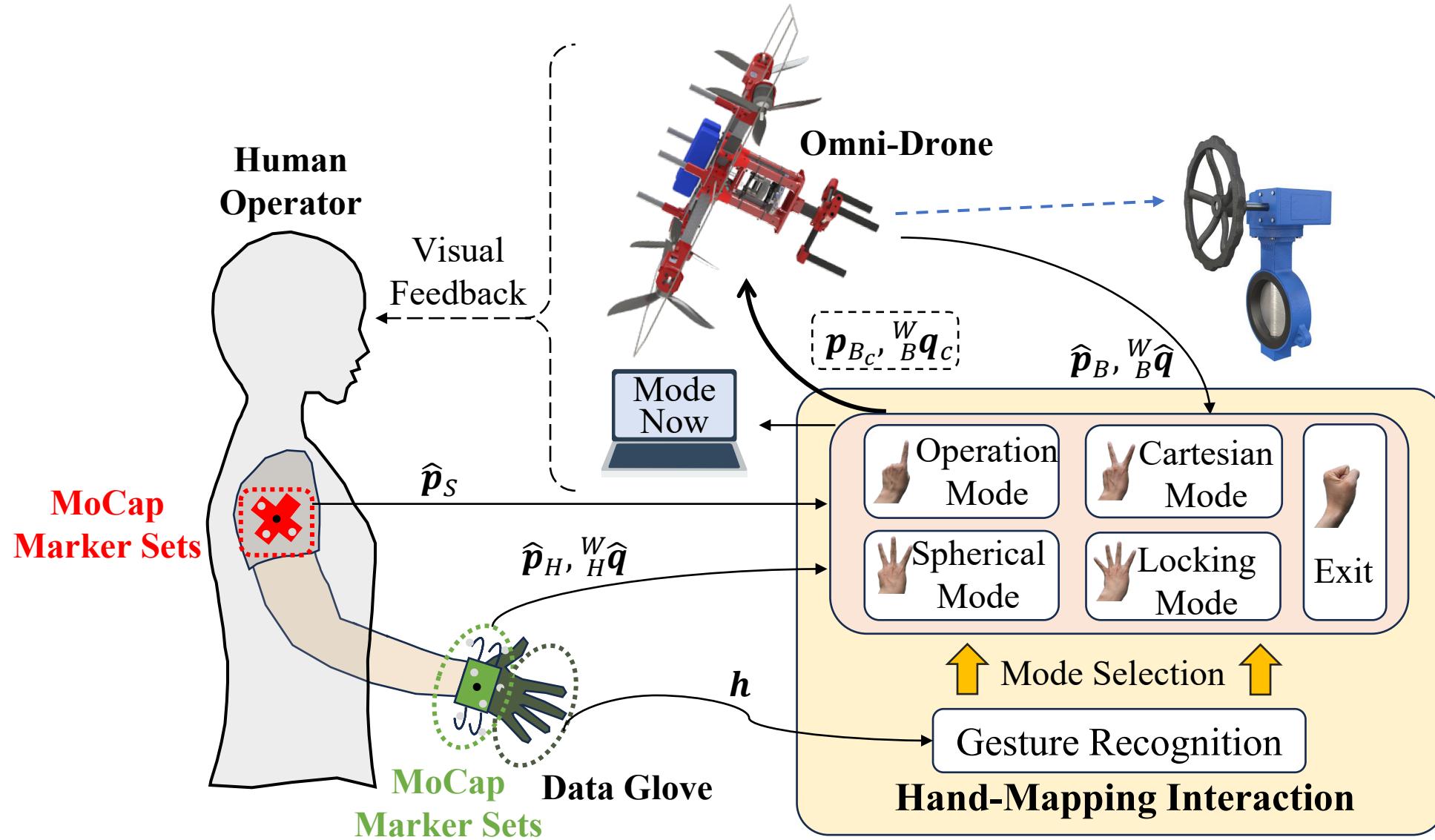


$$\mathbf{p}_{B_c} = \hat{\mathbf{p}}_B(t_0),$$

$${}^W_B \mathbf{q}_c = {}^W_B \hat{\mathbf{q}}(t_0).$$



Omnidirectional Aerial Teleoperation





Six-DoF Hand-Based Teleoperation for Omnidirectional Aerial Robots

Jinjie Li^{1†*}, Jiaxuan Li^{2†}, Kotaro Kaneko^{1,3}, Haokun Liu¹, Liming Shu², and Moju Zhao¹

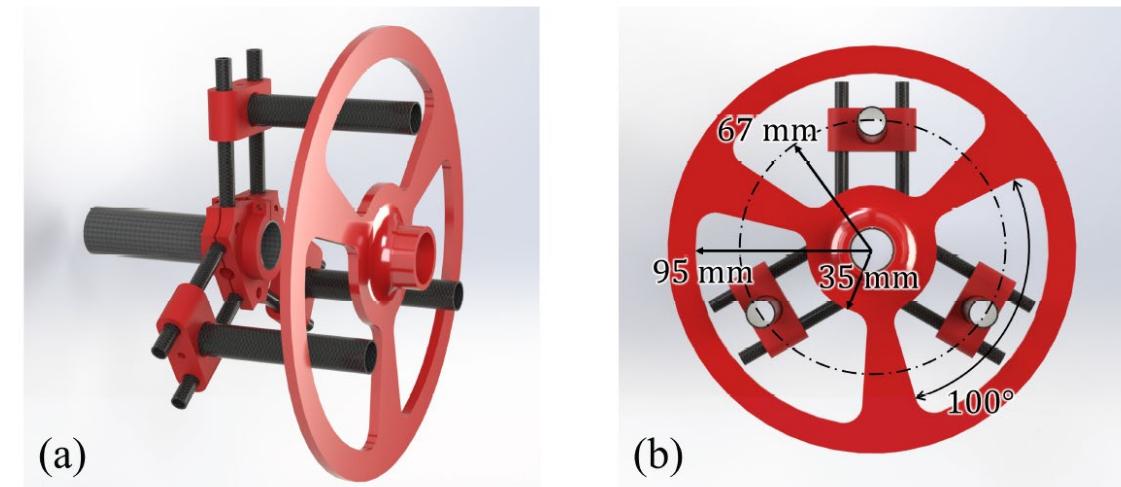
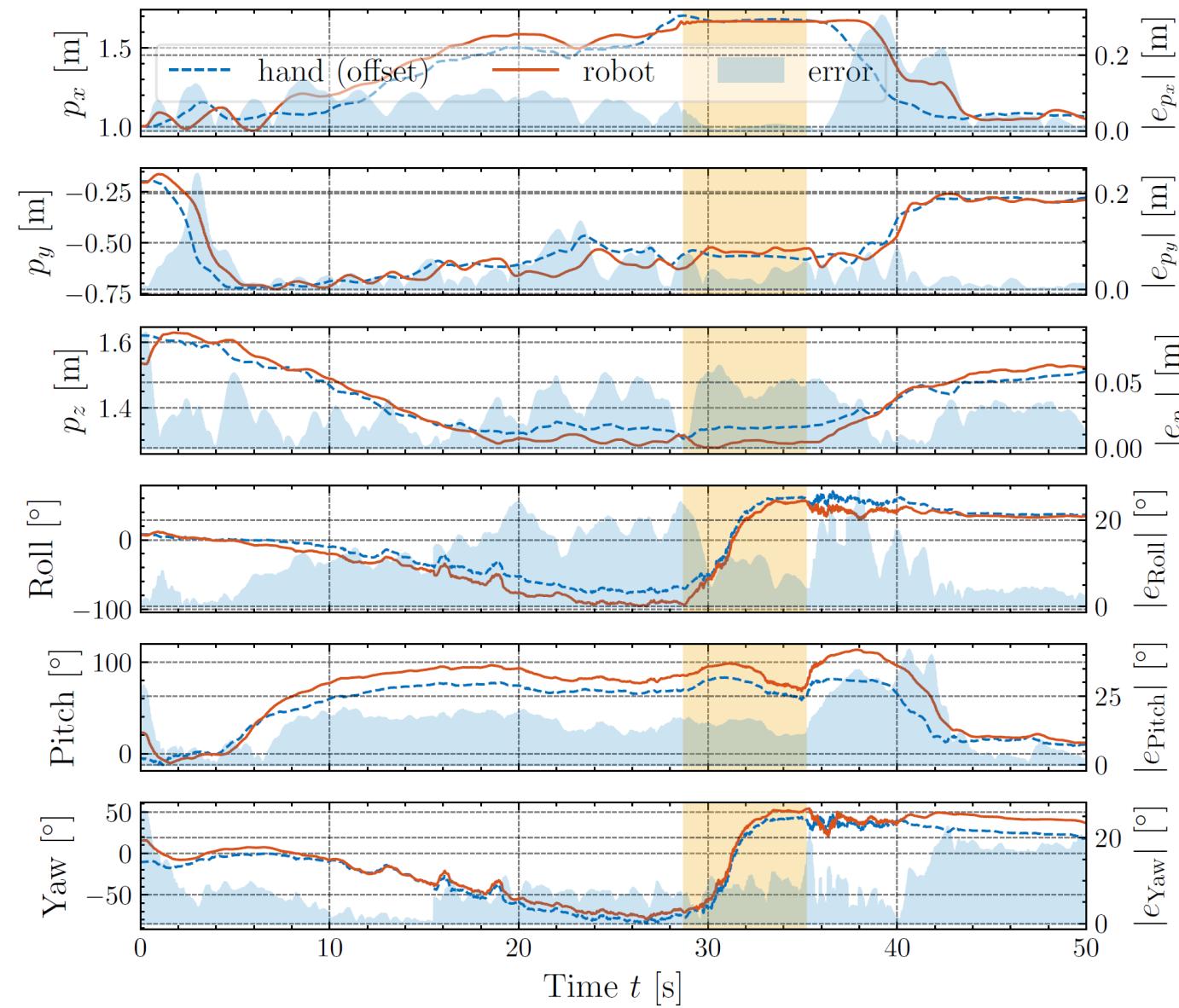
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³HNL Lab, Department of Mechanical Engineering, The University of Tokyo

Result



- Control is stable but has offset
- RMSEs (all positional axes) are over 3 cm, $>$ maximum tolerance
- Human operator can deal with this offset and ensure the safety

Conclusion

Six-DoF Hand-Based Teleoperation for Omnidirectional Aerial Robots

IROS 2025, Hangzhou

Key Takeaways

- To our best knowledge, this is **the first time** the rotational dexterity of human wrist → an omnidirectional aerial robot.
- Precise operation: Locking mode matters!
- Long-range moving: Spherical mode → natural, and Cartesian mode → moving along regular geometries like squares.

Future Directions

- Shared control: rotations that exceed the natural flexibility
- Force and torque support
- Fully onboard flight; video streaming

Workshop Friday 106 ~12:30

