MARS²: Agile and Robust Flight Control of Modular Aerial Robot Systems

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MOTIVATIONS

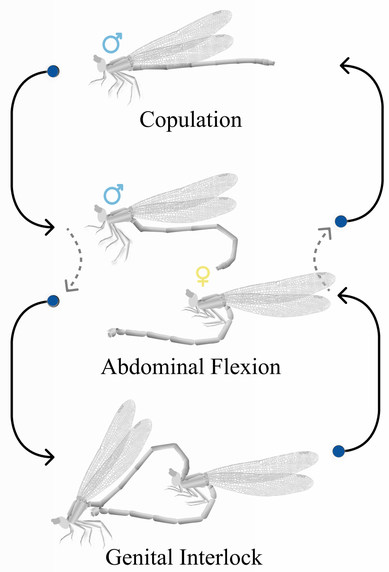
Objective

Biological mating behaviors provide effective mechanisms for precise docking and separation. Inspired by this, **Modular Aerial Robot Systems** (MARS) docking and separation mechanisms aim to **replicate the accuracy and reversibility** of biological interactions, enabling modules to **dynamically assemble and disassemble to perform collaborative tasks.**

Existing challenges

- Limited accuracy during initial docking
- Unreliable locking and separation
- Trade-offs between weight and efficiency
- Arbitrary configurations control

	Biological Inspiration	Our Mechanism
Initial Docking	Male Dragonfly Grasp The Female's Back Plate	Docking Guidance Head; Stable Initial Connection
Locking	Precisely Align & Lock The Connection Securely	Passive Mechanical Locking
Separation	Male Dragonfly Rotates Its Tail To Disengage Smoothly After Mating	Actively Actuated, Repulsion-Assisted Separation

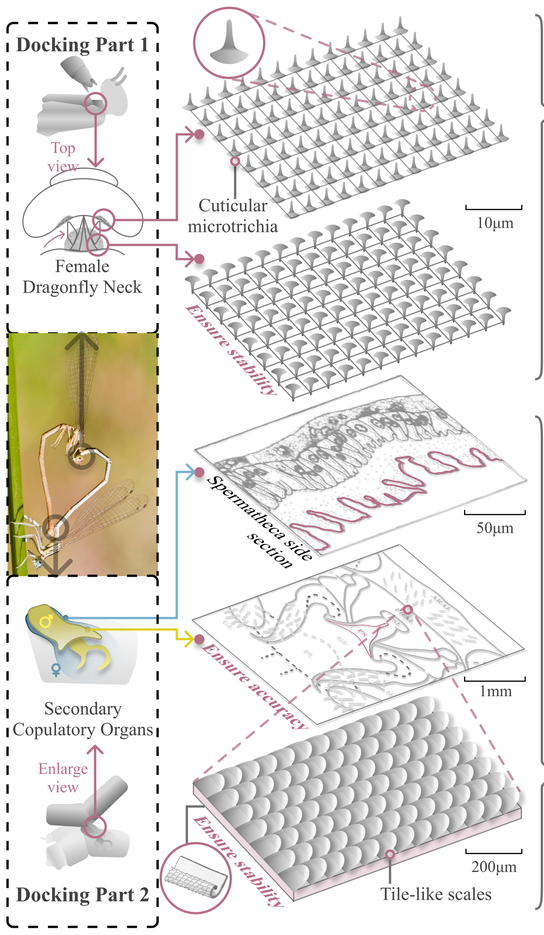


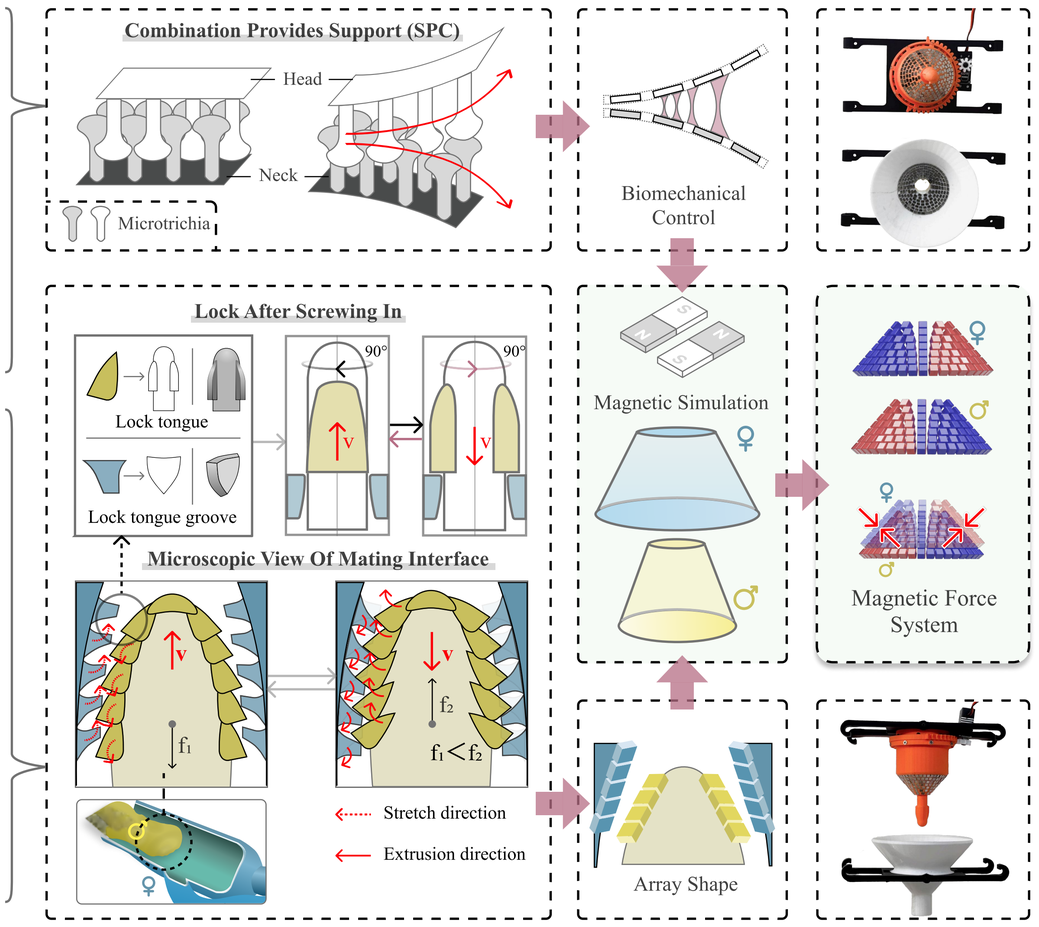
- **Reversible Behavior** — Rotational Reversibility
- **Coupling Precision**
- **Interlocking Stability**
- **Disengagement Flexibility**

By integrating **bio-inspired design principles** and **engineering optimizations**, this study proposes a robust solution for **MARS**. The design enhances system adaptability for **dynamic mission** requirements while offering insights into **collaborative systems** for broader robotics applications.

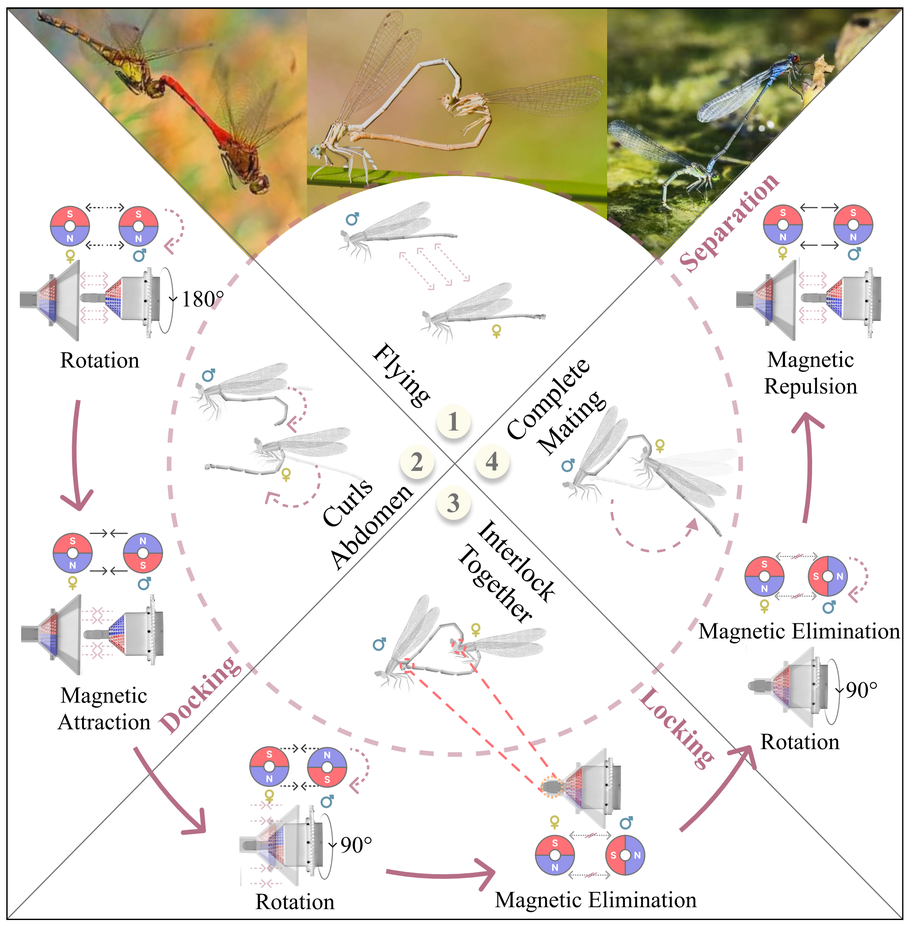
BIO-INSPIRED SOLUTIONS

Design Conception

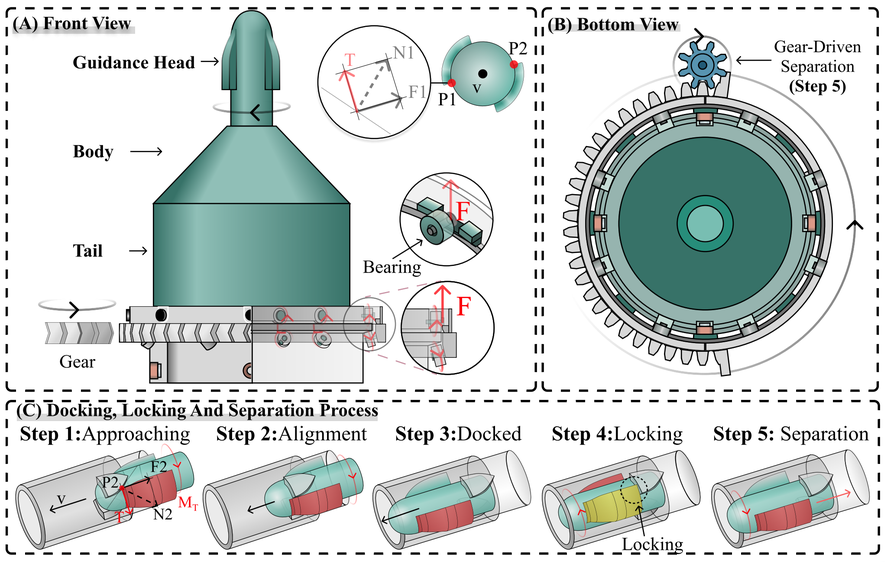




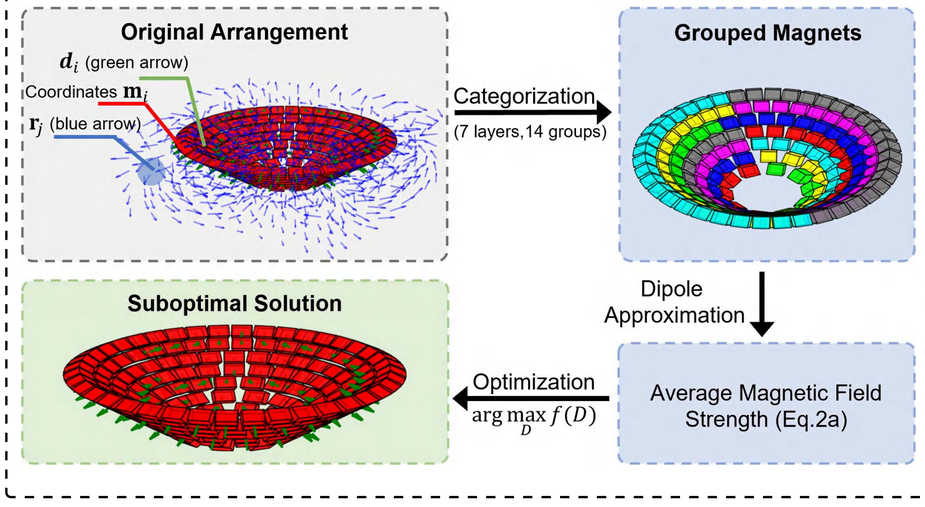
Bionic mechanical pairing mechanism

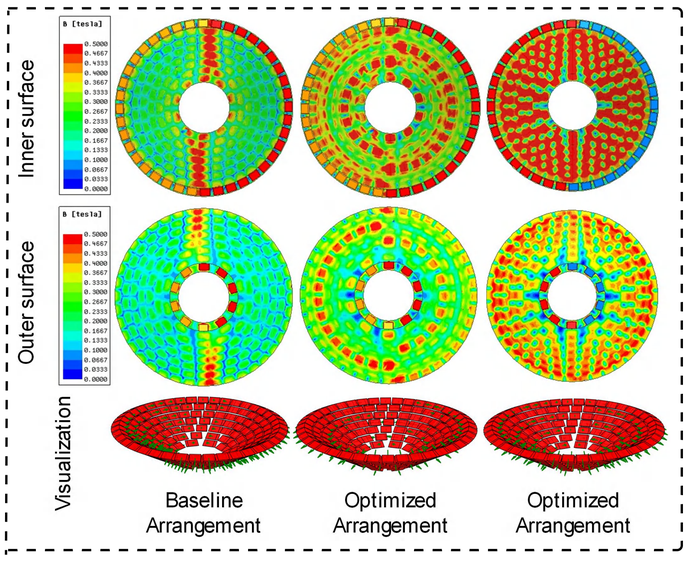


Docking mechanism design



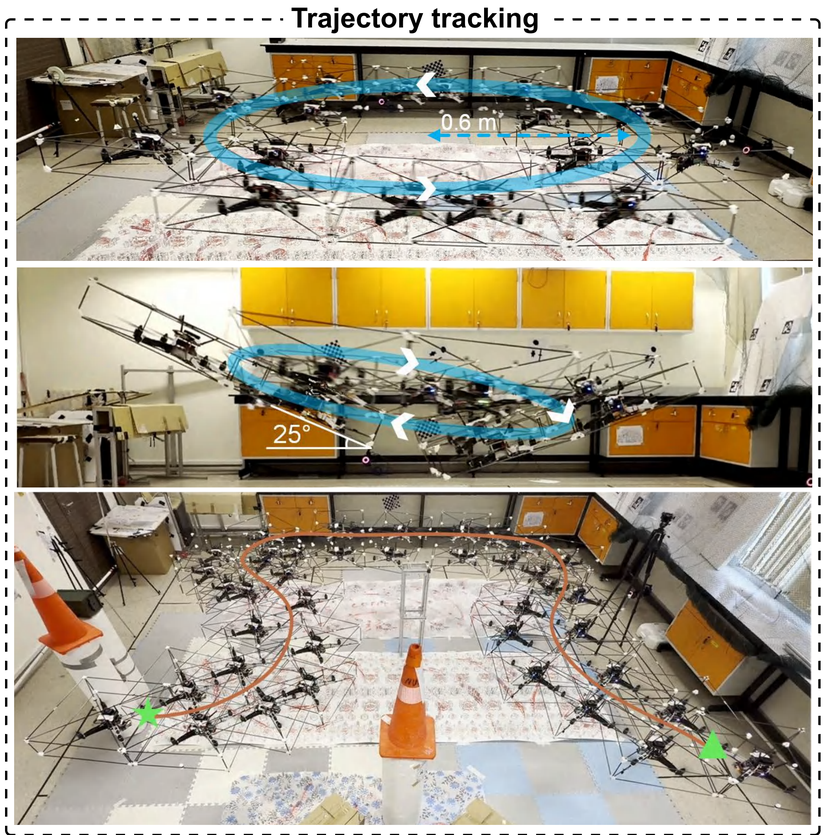
OPTIMIZATION OF MAGNETIC ARRAY LAYOUT



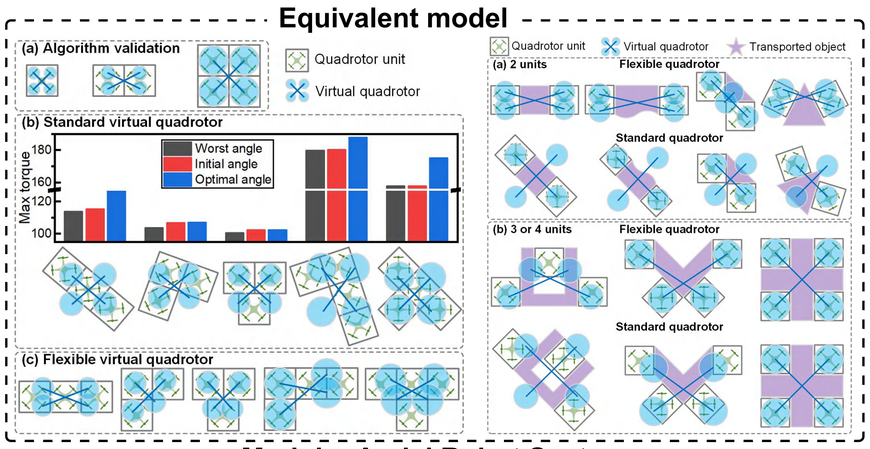


EXPERIMENTAL RESULTS

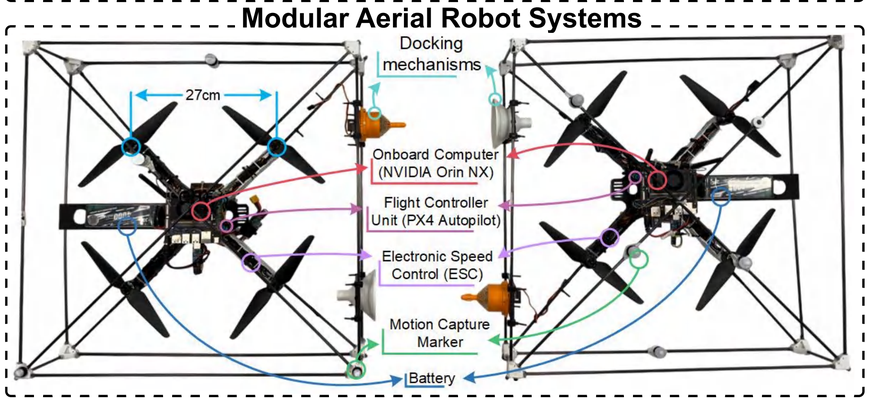
Trajectory tracking



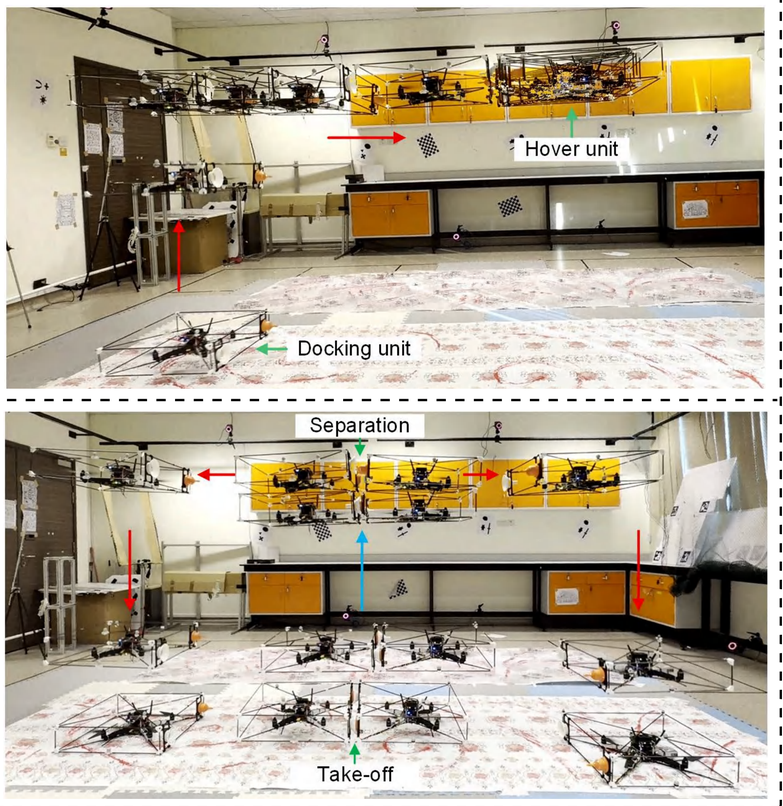
Equivalent model



Modular Aerial Robot Systems



DOCKING AND SEPARATION TEST



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