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Simulating the Manipulation of Flexible Bodies Through Drones

ICRA 2022 Workshop "New frontiers of parallel robotics" (2nd edition)

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Figure 1: Jimenez-Cano *et al.*, "Control of an Aerial Robot with Multi-link Arm for Assembly Tasks" (2013).

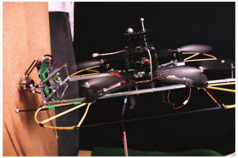


Figure 2: Fumagalli *et al.*, "Developing an Aerial Manipulator Prototype" (2014).

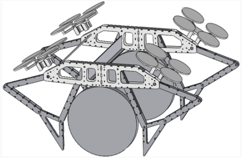


Figure 3: Saint-Sevin *et al.*, "Design and Optimization of a Multi-drone Robot for Grasping and Manipulation of Large Size Objects" (2018).

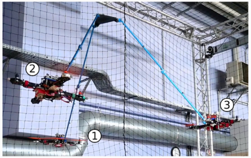
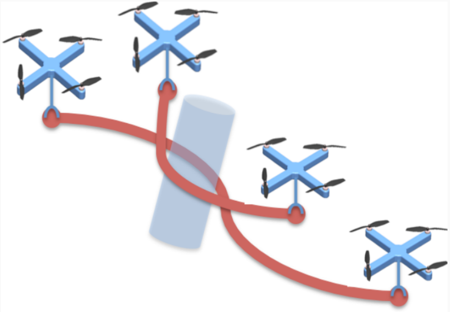


Figure 4: Saint-Sevin *et al.*, "Design and Optimization of a Multi-drone Robot for Grasping and Manipulation of Large Size Objects" (2018).

What we Imagine

A modular/adaptive aerial grasping device implemented as a soft gripper.



What we imagine

- Build “aerial fingers”: flexible bodies manipulated by drones
- Collaboratively controlling fingers: “aerial hand”
- Multi-scale problem
  1. Drone
  2. Flexible body
  3. Manipulation/Collaboration
  4. Path/trajectory planning

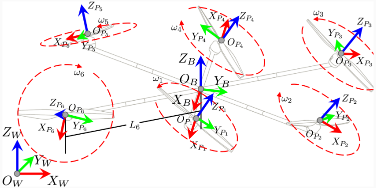


Figure 5: Kinematic model of a hexarotor used in the current preliminary studies.

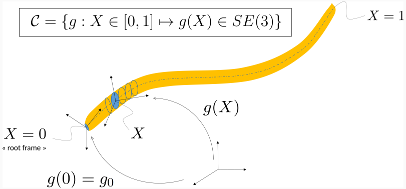


Figure 6: Model of a flexible body based on the Cosserat theory.

Challenges

- Rigid-flexible multibody system
  - Simple model of rigid-body for drones
  - What model for flexible body to describe rigid-body transformations and elastic-body deformations?
- Underactuated system
  - Drones may be underactuated (quadrotor vs. hexarotor)
  - Flexible body very underactuated
- Numerical efficiency
  - Conventional mass-spring-damper system for flexible body
  - Numerical evaluation of explicit dynamics very expensive
- Shape control of flexible body

Preliminary Results

Figure 7: Preliminary simulation results of manipulating a flexible body using arbitrary wrench generators on either end.

Preliminary Results

Figure 8: Preliminary simulation results of manipulating a flexible body using drones (hexarotors).

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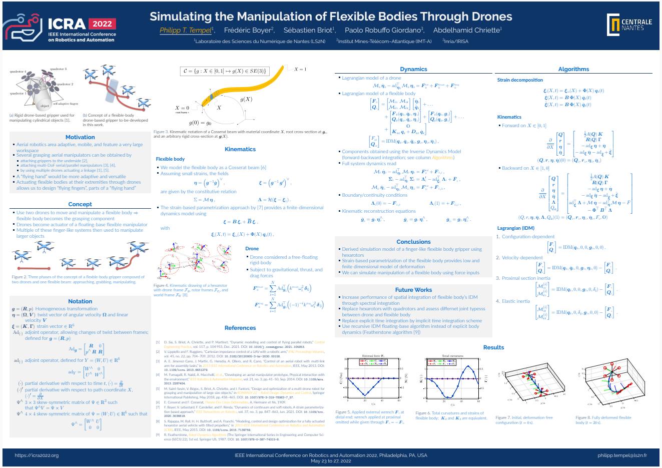

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Let's talk about:

- Manipulating flexible bodies
- Aerial manipulators
- Rigid-flexible multibody systems
- Model and algorithmic perspectives