Fundamentals of Airborne Manipulation: Learning and Cooperation

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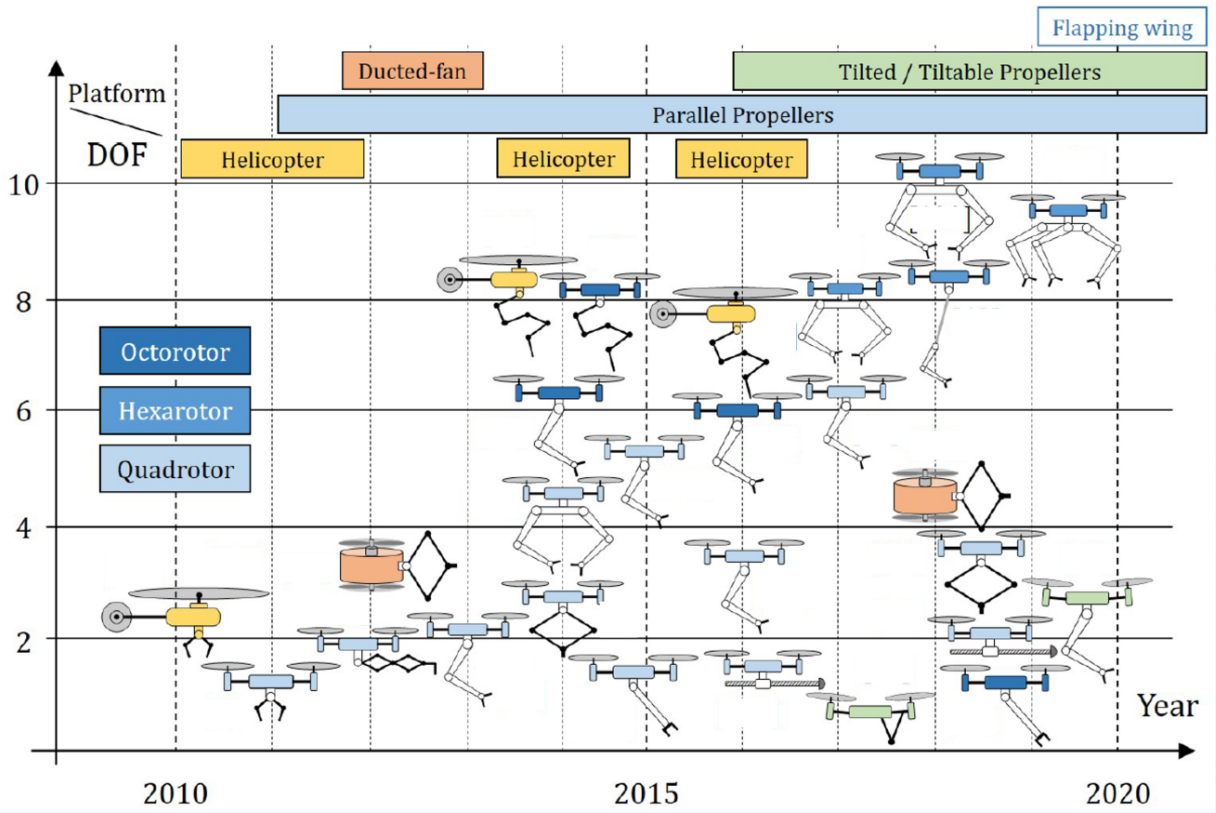
Authors: Isaac Seslar (MS in ME), Michal Rittikaidachar (MS in ME), Riley Martin McCarthy (MS in ME), Rafael Fierro (UNM, Dept of ECE), Steven Spencer (Sandia, 06533)

Fall 2021 LDRD Virtual Poster Session

Introduction and Motivation

- The Fundamentals of Airborne Manipulation (FAM) LDRD develops novel methods to enable high-performance manipulation by small rotorcraft *on-the-fly*.
- FAM has experience 10 years of increasing interest and substantial research.
- Many challenges are yet to be addressed.



A. Ollero et al., "Past, Present and Future of Aerial Robotic Manipulators," *IEEE Trans. on Robotics*, 2021.

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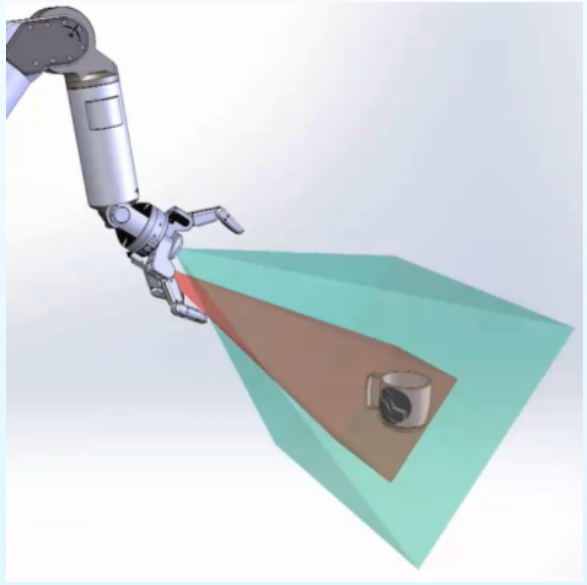
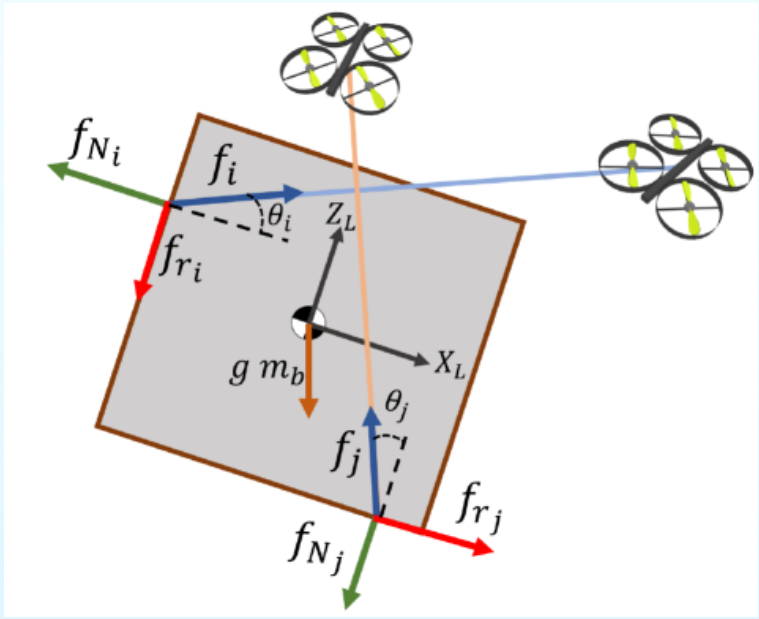
Introduction and Motivation

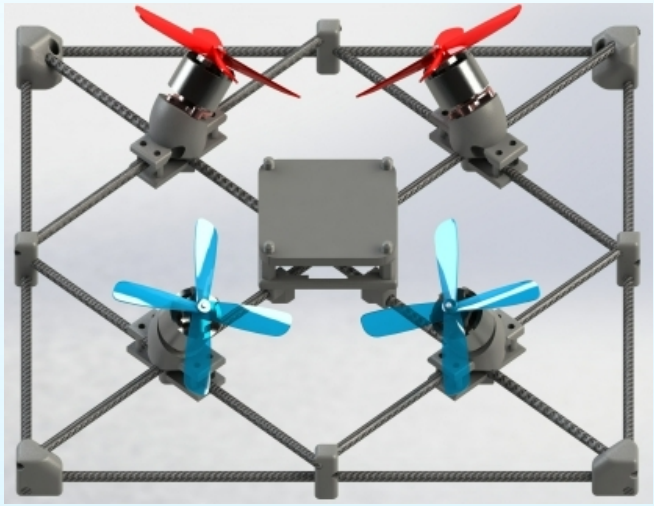
- Three problems are being addressed in this work:

1. Vision and touch-enabled AM.
2. Cooperative multi-vehicle AM.
3. Higher DOF multirotor



Barrett PerceptionPalm™





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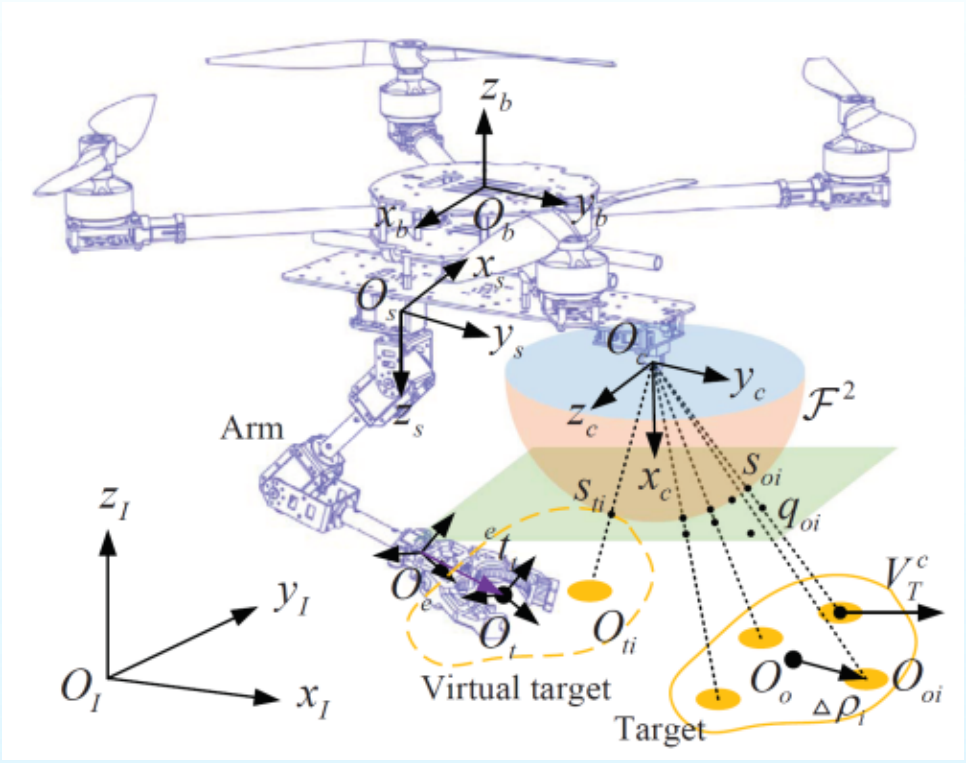
Approach

1. Develop a simulation testbed alongside a hardware testbed. Design a proof of concept.
2. Develop vision and touch-enabled AM. Utilize visual and haptic feedback along with supervised learning to perform non-trivial tasks, such as peg insertion.
   i. Impedance control utilization can improve the performance of the testbed over conventional methods.
3. Utilize cooperative AM and aerial *transportation* of suspended loads.
   i. e.g., Opening a heavy hinged lid, opening a door, etc.



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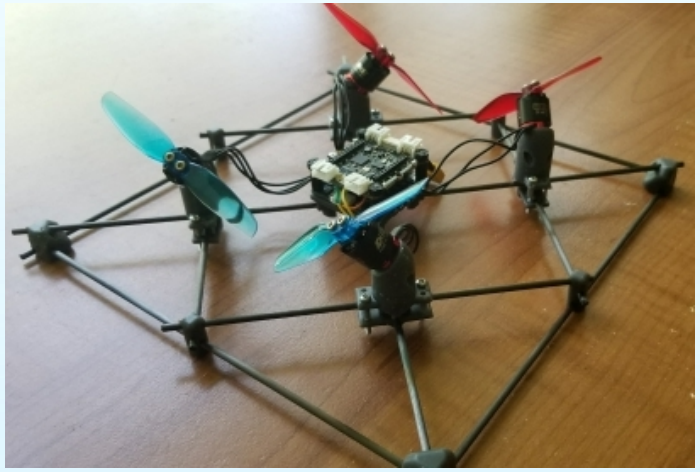
Current Status

The development is underway!

- The arm and both quadrotors have been built.
- Flight tests have begun using the quadrotor w/ mounted arm.
- Flight code development is advancing on omni-directional quadrotor.



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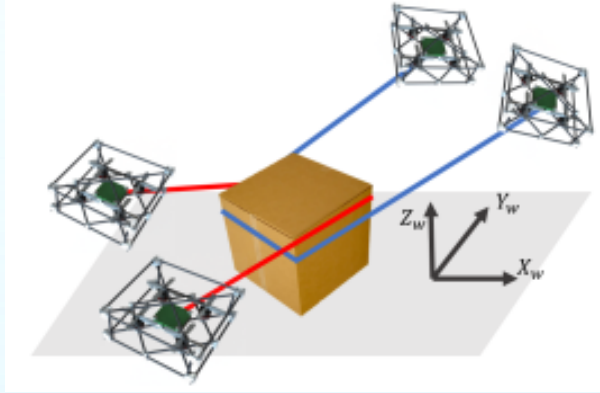
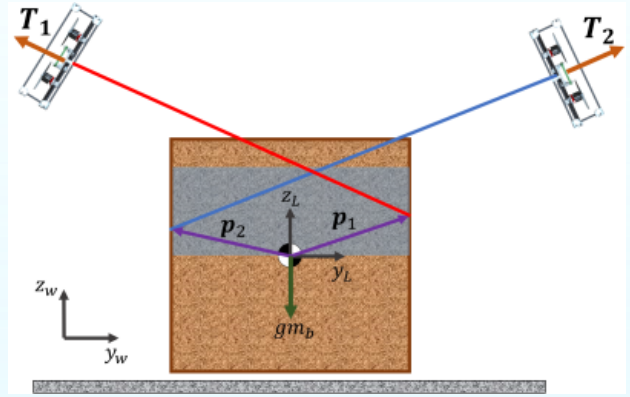
Current Status

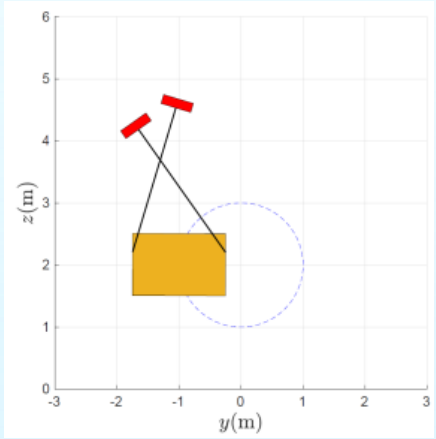
- Adaptive Control for Cooperative Aerial Transportation

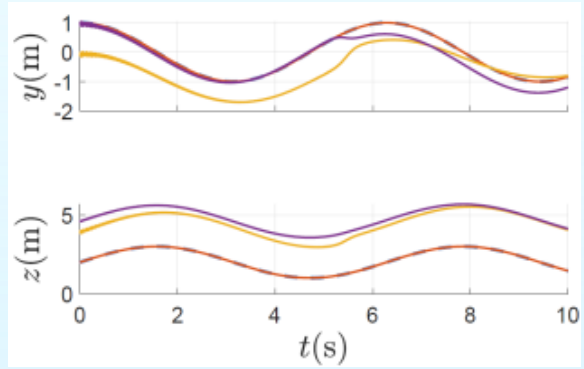
  1. Quadrotors wrap cables around the object.
  2. Contact points between the cable and the object are unknown.
  3. Mass and inertia of the load is unknown.

- Collaboration with the Autonomous and Intelligent Robotics Laboratory – AIRLab at Lehigh University, PA, USA









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Impact of Work

- Tasks can be performed deemed too dangerous or difficult for humans, for example:
  i. Wind turbine repair
  ii. Toxic waste disposal
  iii. Package distribution
- Autonomy can be integrated in day-to-day tasks

Sulzer Schmid, Autonomous blade inspection

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Challenges and Risks

- Challenges and Risks include:
  - i. Developing safe algorithms that won't put people in danger.
  - ii. Flight algorithms that won't cause the entire system to go unstable due to CG movement.
  - iii. Custom flight algorithm development for omni-quad.

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Next Steps and Future Work

Next Steps:

- Perform tasks with the quadrotor, such as:
  i. Writing on a whiteboard.
  ii. Tightening a screw.

- Perform flight tests with the omni-directional quadrotor.
  i. This proof-of-concept shows the quadrotor's capability