Distributed Geometric and Optimization-based Control of Multiple Quadrotors for for Cable-Suspended Payload Transport

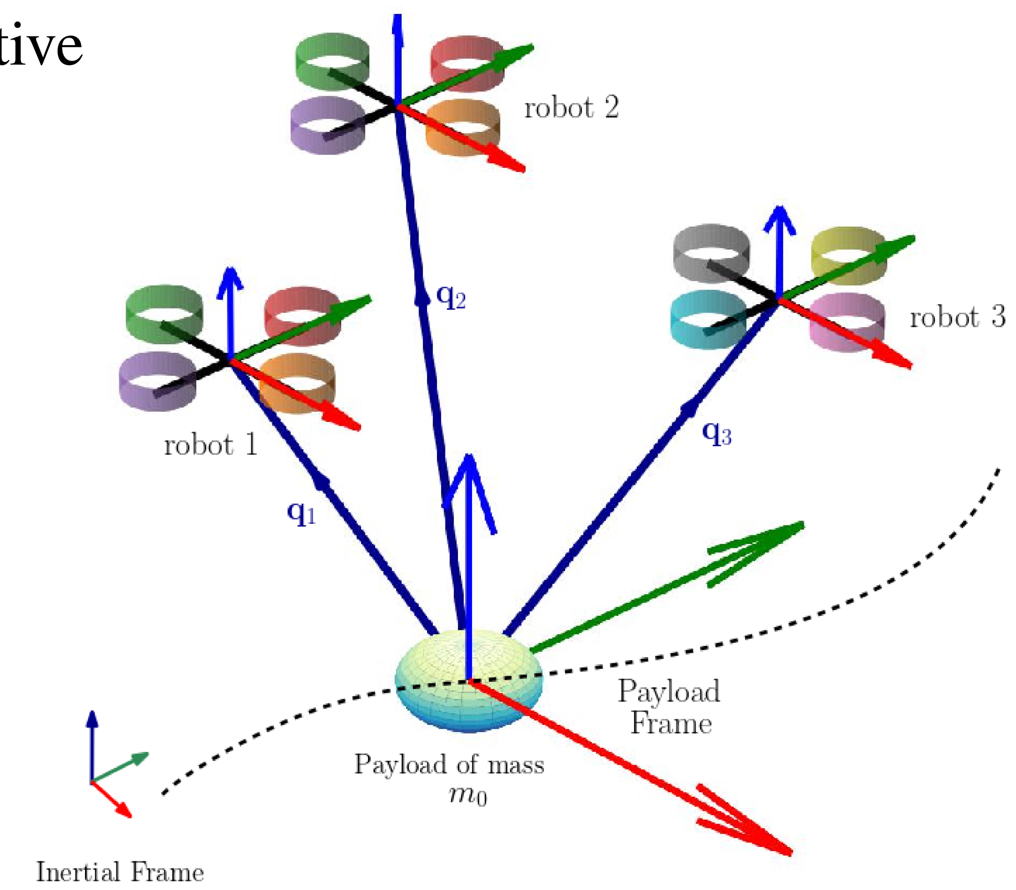
Authors

Khaled Wahba, Wolfgang Hönig

Technische Universität Berlin

Introduction

- Multi-UAVs are well suited for collaborative applications:
  - Assisting in construction sites,
  - Payload collaborative transportation.
- **Cable-Suspended** payload transportation:
  - Not using manipulators/grippers,
  - Transportation of heavy objects.

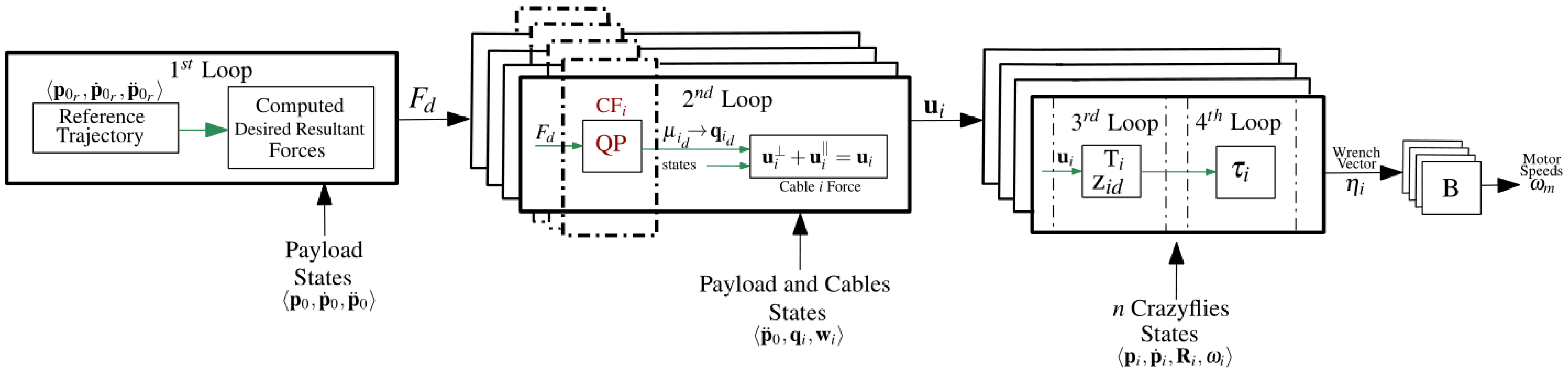


Background

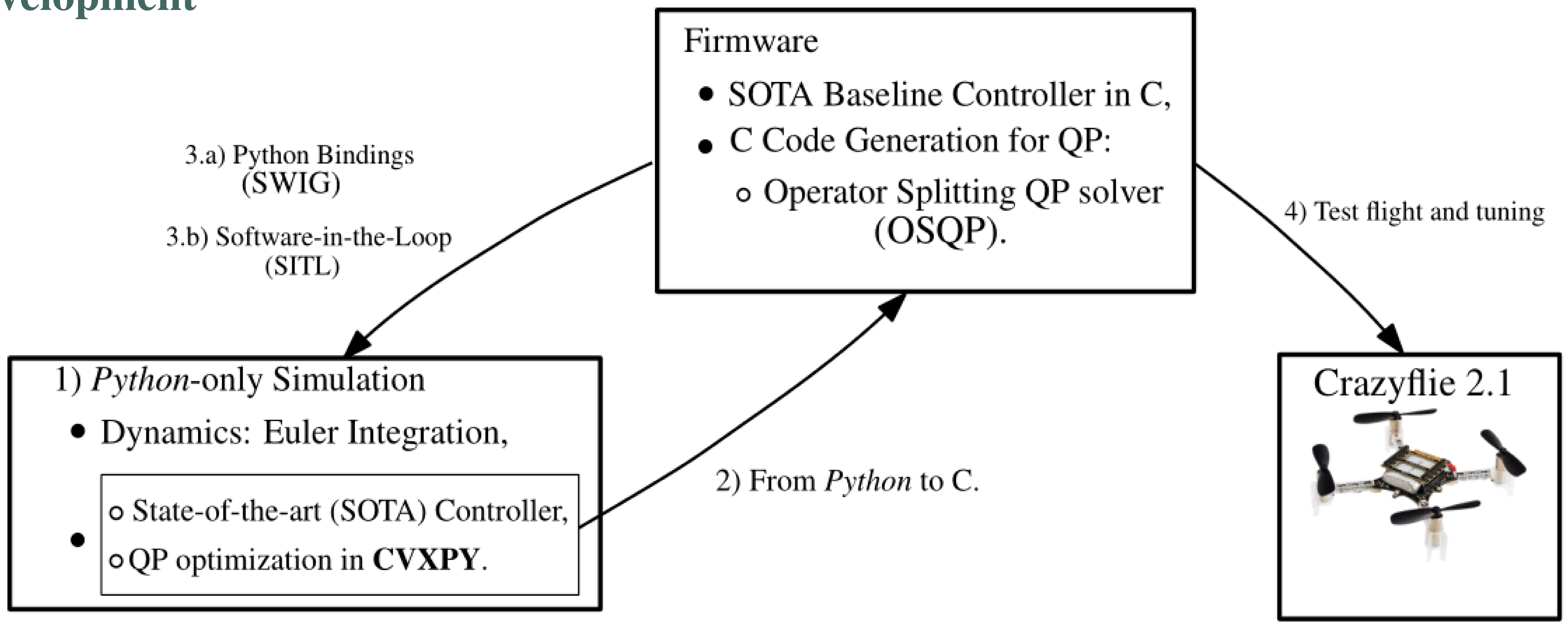
- Given:
  - n quadrotors carrying a cable-suspended payload,
  - Reference trajectory: $\langle \mathbf{p}_{0_r}, \dot{\mathbf{p}}_{0_r}, \ddot{\mathbf{p}}_{0_r} \rangle$.
- **Objective**: payload to track the reference trajectory.
- State-of-the-art [1], [2] does not take into account:
  - Inter-UAV and UAV-obstacle collisions,
  - Cable tangling,
  - Formation changes between configurations,
  - Payload physical size.

Approach

- Distributed Quadratic Optimization Problem (QPs) Formulation:
  - Computation of desired cable forces μ_{id},
  - **Constraints**: - Payload trajectory tracking,
    - Inter-UAV, obstacle collision avoidance.

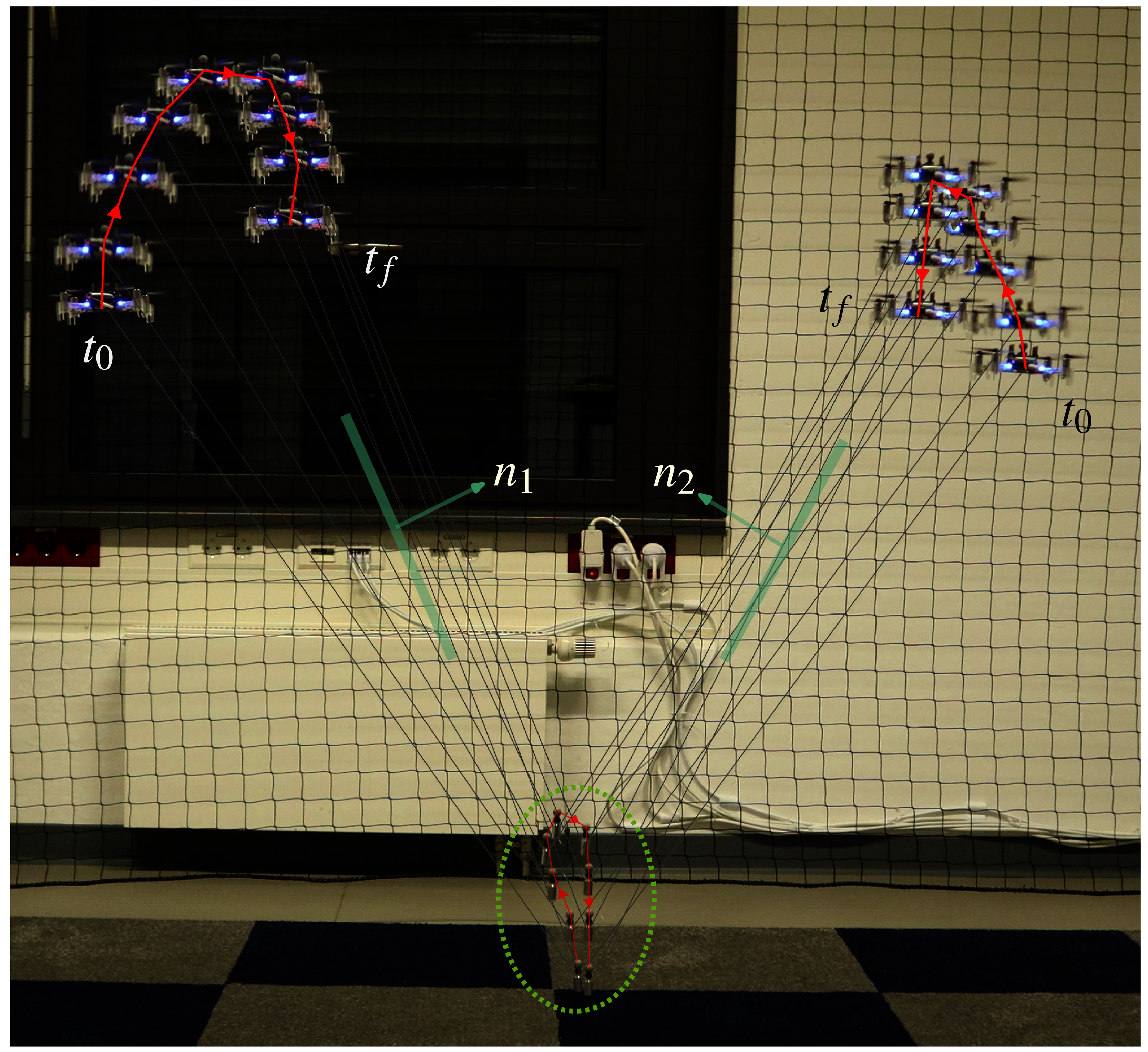


Sim-to-Real Development



Experiments

- 2 CrazyFlies (CFs) of mass $m_i = 34$ g carrying a $m_0 = 10$ g payload,
- length of cables $l_1 = 0.77$ m, $l_2 = 0.705$ m,
- STM32 microcontroller (168MHz, 192kB RAM),
- **Objective**: Track hovering reference trajectory,
- **Constraints**:
  - Normal vectors $\mathbf{n}_1, \mathbf{n}_2$ for desired hyperplanes,
  - Reference trajectory.



Results

- Each CF runs QPs on-board to compute optimal μ_{i_d},
- The computed optimal solution of the QPs respects the constraints.

References

[1] T. Lee, K. Sreenath, and V. Kumar, "Geometric control of cooperating multiple quadrotor uavs with a suspended payload," in Proc. IEEE Conf. Decis. Control, 2013, pp. 5510-5515.

[2] T. Lee, "Geometric control of quadrotor uavs transporting a cable-suspended rigid body," IEEE Transactions on Control Systems Technology, vol. 26, no. 1, pp. 255-264, 2017.