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Ph.D. DISSERTATION DEFENSE

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Date:	Dec 6, 2023
Time/Location:	10:00 AM via Zoom https://stevens.zoom.us/j/91431997591
Title:	Suspended Load Transportation with Cable-Driven Robots Powered by Quadrotors
Chairperson:	Dr. Damiano Zanotto, Department of Mechanical Engineering, SES
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ABSTRACT

Suspended load transportation (SLT) with autonomous quadrotors has the potential to revolutionize transportation by reducing the weight and complexity of traditional systems. This approach replaces rigid-link robotic arms with lightweight actuated winches and cables, enabling more efficient and versatile load handling. However, this innovation introduces challenges such as highly coupled and underactuated dynamics, load swing, and varying wrench closure conditions. These issues can be addressed by leveraging the modeling convention of reconfigurable cable-driven robots (RCDPR) and advanced control methods. However, past research has largely overlooked these opportunities.

This dissertation addresses motion planning and control for SLT systems consisting of single or multiple quadrotors to carry a cable-suspended load. First, we introduce a novel reinforcement learning-based controller for trajectory tracking, achieving superior performance under disturbances compared to a conventional controller. Second, utilizing the RCDPR modeling convention, we develop a new online trajectory generation method based on dynamic control allocation for cooperative transportation with multiple quadrotors. Third, we present an optimization-based planning method for a single-quadrotor SLT system with actively controlled cable length. This method enables the quadrotor to achieve more stable maneuvering and lower energy consumption compared with a constant cable length quadrotor. Lastly, we introduce a novel admittance control strategy for quadrotor-human collaborative transportation of a suspended load. Compared to traditional approaches, our method offers a compliant cable length that may enhance safety and efficiency during collaborative loading/unloading and transportation. Overall, this work provides new algorithmic support for quadrotor-based SLT systems, enabling more efficient and robust motion planning and control.