MECHANICAL ENGINEERING PhD SEMINAR

Thursday, November 19 2026 at 13:30, Dan Kahn Building, Auditorium 1

Zoom Link: https://technion.zoom.us/j/94510895951

Manipulation of Flexible Rod-Like Objects Using Robotic Arms

Extended to Control-Rate Physics-Informed Neural Networks

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Flexible rod-like objects such as cables, wires and hoses appear in assembly, maintenance and household tasks, yet their manipulation by robot arms remains difficult. Unlike a rigid body, the shape of a flexible object is determined by the positions and orientations of the robot dual-arm grippers that hold it, and the same gripper configuration may admit several equilibrium shapes, some of them unstable. A manipulation plan must therefore keep the object in a stable, collision-free and non-self-intersecting equilibrium along the entire motion.

In this seminar, I will present a framework for dual-arm manipulation planning of flexible rod-like objects that is based on mechanics and optimal control. In the planar case, the equilibrium shapes are Euler's elastica, which are available in closed form through Jacobi elliptic functions. I will show how the elastica shape parameters define a low-dimensional configuration space for the object, how local stability is characterized by conjugate points, and how exact conditions for self-intersection lead to a safe configuration space. A* and bidirectional RRT planners operating in this space steer the object between obstacles, and the resulting plans were executed on a Baxter dual-arm robot.

In three dimensions, no closed-form solution exists. I will present a quaternion-based optimal-control formulation of the elastic rod and physics-informed neural networks that map points in the configuration space to both the equilibrium shape and its stability, much faster than numerical integration. These networks are embedded in a dual-arm planner whose plans are validated in a physics-based simulation.

This extension to Control-Rate PINNs (Physics-Informed Neural Networks) is conducted in collaboration with Barcelona Tech University (UPC).

Seminars Coordinator: Prof. Sefi Givli