Model Predictive Control of an Underdamped, Pneumatically Actuated, Soft Robot with Flexible Links for Unmodeled Environments

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Research Objectives
- Develop optimal control methods for soft robots to enable fast, precise motion despite the difficult underdamped dynamics of the system.
- Apply these control methods to achieve unprecedented performance in real and unmodeled environments for soft robot manipulation and locomotion.
- Test the controllers in realistic and useful scenarios (such as equipment maintenance or installation, or exploration of rugged terrain), that will have wide applicability to future space missions.

Approach
- Model soft robots using approximate linear and non-linear models.
- Incorporate these models into Model Predictive Control (MPC) framework using state-of-the-art real-time optimization for robot manipulation in unmodeled environments.
- Compare MPC to other state-of-the-art controllers for underdamped systems.
- Build new capabilities on top of low-level MPC controllers such as 1) collaboration between different soft robots and 2) soft robot locomotion.

Potential Impact
- Capable robots can provide significant benefits for space exploration in terms of human assistance and collaboration, rugged terrain exploration, or equipment maintenance.
- The proposed controllers will enable cheaper, lighter (10 times lighter), smaller (10 times smaller packing volume) robots for important missions.
- The proposed control methods and testing will also be applicable in other important areas such as search and rescue or disaster relief.