Modeling and Control of Soft Robots

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Inspired by nature, elastic elements are purposefully introduced into the physical structure of soft robots. The goal is to obtain *natural* motions by embodying in the morphology of the robot the intelligent principles of motor control in humans and animals. Two main branches exist in soft robotics research according to their main source of inspiration: articulated (inspired by vertebrate muscle-skeletal systems) and continuum (inspired by invertebrates or boneless animal body parts).

The course will deal with modeling and control of soft robots. Modeling soft continuum robots is especially challenging due to the infinite dimensional nature of their state. The exact formulation is intractable or inapplicable to most practical and meaningful applications. Finite dimensional approximations have been proposed as an alternative. The obtained models have structures that resemble those that we are used to in classical robotics, displaying at the same time some peculiarities which open exciting research challenges for model-based control.

We will cover the following topics.

- The physics behind soft robots modeling: the continuum formulation of soft robot dynamics
- Discretization strategies for control-oriented modeling
- Dynamic control in the fully actuated approximation: Feedforward and feedback strategies
- The underactuated case: Quasi-static and dynamic control problems

The course will also include six seminars, focusing on a specific research challenge in articulated and continuum soft robotics, and delivered by experts in the field.

Prerequisites: Good knowledge of basic math, classical mechanics, multi-body dynamics, and an acquaintance with control theory are assumed. Having been exposed to nonlinear control problems is helpful but not mandatory.