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Control of Soft and Articulated Elastic Robots

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Abstract of the course

Humans and other animals still substantially outperform classic robots in performance, reliability, and efficiency. Interestingly, their physical characteristics differ substantially from those of robots. Elastic tendons, ligaments, and muscles enable animals to interact robustly with the external world and perform dynamic tasks. On the contrary, traditional robots have generally been very stiff and heavyweight. Therefore, robotics researchers have departed from the as-stiff-as-possible principle in favor of lightweight and compliant structures. Taking inspiration from the natural example, elastic and soft components are included in the robot design, yielding flexible joint or flexible link robots and, more recently, articulated and continuum soft robots. The latter are entirely made of continuously deformable elements, bringing them close to invertebrate animals. This recent explosion of new robotic concepts opened up the avenue of developing effective control strategies to manage the soft body, a nonlinear mechanical system with a large – possibly infinite – number of DOFs and, as a result, also a large degree of underactuation from the control point of view. This course aims at introducing such control challenge. We will review established results in the field, introduce the most recent advances, and discuss interesting open issues.

Topics

- Introduction to robotics beyond rigid robots
- Flexible joint and articulated soft robots: dynamic model, structural properties, control
- Flexible link robots: dynamic model, structural properties, control
- Modelling soft robots: Constant curvature, strain discretization, general form of equations
- Controlling soft robots: shape regulation (general case and subclasses), shape tracking, and task-space control