

Geometric Theory of Soft Robots

Dottorato di Ricerca in Ingegneria Strutturale, Geotecnica e Rischio Sismico
Università degli Studi di Napoli Federico II

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Instructor	Stanislao Grazioso (email: stanislao(dot)grazioso(at)unina(dot)it)
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Duration/Credits	13 hours divided in 4 lessons / 4 CFU

Course Description

Inspired by biological trunks and tentacles, soft robots exhibit novel capabilities with respect to traditional rigid robots, such as traverse confined spaces, manipulate objects in complex environments and conform their shape to nonlinear paths. These desirable characteristics are due to their ability to undergo a large deformation under normal operation. This short course provides theoretical foundations on modeling and simulation of soft robots, combining concepts from the screw theory and differential geometry in a finite element fashion.

Course Requirements

Basic knowledge of: (i) algebra and calculus; (ii) fundamental principles of mechanics; (iii) concepts of kinematics, statics and dynamics; (iv) finite element method.

Course Objectives

To learn about advanced modeling of soft robots; to work individually and in groups to realize analytical and numerical simulations of soft robots.

Course Timetable

1. F 06/04/2018 15:30–18:30, Aula Multimediale, Piano Primo, Edificio 7, DIST, Via Claudio
2. T 12/04/2018 08:30–10:30 and 13:30–15:30, Aula Multimediale, Piano Primo, Edificio 7, DIST, Via Claudio
3. F 13/04/2018 15:30–18:30, Aula A3, Piano Terra, Edificio 6, DIST, Via Claudio
4. F 20/04/2018 15:30–18:30, Aula A3, Piano Terra, Edificio 6, DIST, Via Claudio

Course Schedule

1. The geometric framework

Lie group and Lie algebra; special Orthogonal group $SO(3)$ and special Euclidean group $SE(3)$; twists, wrenches and screws; exponential coordinate representation; rigid body transformations; variations; modeling of a rigid link: kinematics, kinetic and potential energy, Hamiltonian formulation for single rigid body dynamics, geometric time integration.

2. Modeling of a soft link - continuum formulation

Position, deformation and velocity fields; compatibility equations; strain energy and stress resultant; static equilibrium equations; kinetic energy; dynamic equilibrium equations; analytically integrable cases; examples and exercises.

3. Modeling of a soft link - discrete formulation

Discretized static formulation; discretized dynamic formulation; geometric time integration; examples and exercises.

4. Modeling of a multi-link rigid-soft manipulator

Relative transformations; Lie subgroup and Lie subalgebra; rigid and elastic joint models; kinematic configuration of the multibody system; equations of motion; geometric time integration; examples and exercises.

Course Assessments

Individual quiz and group project.