Modeling and Control of Flexible and Soft Robots

Dates and time

28-03-2022 from 13.45-16.00
04-04-2022 from 10.15 – 12.00 - please note time change !
11-04-2022 from 13.45-16.00
25-04-2022 from 13.45-16.00

Course location

Cursus- en vergadercentrum Domstad, Utrecht

ECTS

3 ECTS if the homework is completed successfully.
1 ECTS for auditing the course

Lecturers

Cosimo Della Santina, Delft University of Technology
Antonio Bicchi, University of Pisa and Italian Institute of Technology

Objective

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.

Contents

We will cover the following topics:

• Quick recap on Lagrangian mechanics and Lyapunov theory for assessing the stability of nonlinear mechanical systems. We will also provide pre-recorded lectures, so to help students new to these theories to familiarize with the concepts beforehand.
• Elasticity in robotics: advanced robotic concepts, from flexible to soft robots.
• Flexible robots and articulated soft robots: modeling and control.

• Continuum Soft Robots: control-oriented modeling, dynamic control of the shape, task space control.

Prerequisites

Good knowledge of basic math, classical mechanics, multi-body dynamics, and control theory. Largrangian formulation of multi-body dynamics and Lyapunov theory of stability will be reviewed during the first lecture.

Homework assignments

Homework will be assigned every week.