Advanced Modelling of Robots

Credits: 5 Semester 3 (ECN) Compulsory: Yes

Format	Lectures 24 h	Examples 16h	Private study 80 h

Lecturer: S. Briot, S. Caro

Objectives:

This course presents advanced modelling techniques (geometric, kinematic and dynamic) of robots (tree structure robots, parallel robots, and hybrid robots) composed of rigid links.

Contents:

The following topics are treated:

- Description of complex mechanical systems (tree-structured or closed loop systems),
- Geometric and kinematic models of closed-loop structure robots, constraints equations, mobility analysis, singularity analysis (introduction to DHm convention of tree-structured and closed loop systems)
- Workspace analysis of full-mobility and lower-mobility parallel robots
- Calibration of geometric parameters
- Recalls of dynamics principle (Newton-Euler, Euler-Lagrange, Principle of virtual works) for open and closed-loop mechanism systems
- Dynamic modelling of rigid tree-structure robots: the inverse and direct dynamic problems, the base inertial parameters, computation of the ground forces.
- Dynamic modelling of rigid parallel robots without and with actuation redundancy: the inverse and direct dynamic problems, the base inertial parameters, computation of the ground forces.
- Analysis of the degeneracy conditions of the dynamic model of rigid parallel robots, and singularity crossing
- Identification of dynamic parameters

Practical Work: Exercises will be set, involving modelling, identification and simulation of robots. Advanced technical papers from recent international conferences will be analysed and reviewed.

Abilities: After completing this course, the students will be able to:

- Understand the fundamentals of the mathematical models of robots and their applications in robot design, control and simulation.
- Analyse the mobility of parallel robots and understand the notion of operation modes
- Analyse, identify and illustrate the serial and parallel (including the constraint) singularities of parallel robots
- Identify the geometric and dynamic parameters of a robot
- Use of the best methods to develop the required models of a given architecture
- Apply the given techniques to other systems such as mobile robots or passenger cars
- Use the convenient numerical schemes for numerical integration.
- Use modelling, optimization, and signal processing tool boxes software packages (Matlab, Adams).

Assessment: 30% continuous assessments, 70% from end of semester examination.

Recommended texts:

- S. Caro, lecture notes on "*Geometric and Kinematic Modelling of Serial and Parallel Robots*"
- W. Khalil, E. Dombre, *Modelling, identification and control of robots*, Hermes Penton, London, 2002.
- J. Angeles, *Fundamentals of Robotic Mechanical Systems*, Springer-Verlag, New York, 3rd edition, 2007
- Merlet, J. P., 2006, Parallel Robots (Solid Mechanics and Its Applications), Springer, New York, Vol. 128.

- S. Briot, lecture notes on “Advanced Dynamic Modelling of Robots”
- S. Briot and W. Khalil, *Dynamics of Parallel Robots*, Springer.

Further readings:
will be provided during the course