Modeling and control of manipulators

Credits: 6 Semester 1 Compulsory: Yes

Format	Lectures 30 h	Examples 20 h	Private study 100 h

Lecturers: W. Khalil (ECN)

Objectives: This course presents the fundamentals of the modeling and control techniques of serial manipulators. Topics include robot architectures, geometric modeling, kinematic modeling, dynamic modeling and its applications, as well as the classical PID controller and computed torque controller.

Contents:

The following subjects will be treated:

Robot architectures, joint space, operational space,

- Homogenous transformation matrices,
- Description of manipulator kinematics using modified Denavit and Hartenberg notations,
- Direct geometric model,
- Inverse geometric models using Paul's method, Piper's method and general methods,
- Calculation of kinematic Jacobian matrix,
- Inverse kinematics for regular and redundant robots,
- Dynamic modeling using the Lagrange formalism,
- Dynamic modeling using recursive Newton-Euler method,
- Trajectory generation between two points in the joint and operational spaces,
- Classical PID control
- Computed torque Control.

Practical Work: Exercises will be set, which will involve modeling some manipulators, and simulation of control laws.

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

Understand the fundamentals of the mathematical models of serial robot manipulators and their applications in robots design, control and simulation.

Understand the effect of the kinematic parameters on the manipulator characteristics.

- Use the most convenient methods to obtain the required models,
- Understand practical applications of the mathematical modeling of manipulators,
- Use symbolic and numerical software packages (Matlab, Simulink, Maple, Mathematica, …).

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

Recommended texts:

- W. Khalil, and E. Dombre, *Modeling, identification and control of robots*, Hermes Penton, London, 2002.

Further readings:

- C.Canudas, B. Siciliano, G.Bastin (editors), *Theory of Robot Control*, Springer-Verlag, 1996
- J. Angeles, *Fundamentals of Robotic Mechanical Systems*, Springer-Verlag, New York, 2002.