2EL1120 – Interactive Robotic Systems

Instructors: Maria Makarova
Department: DÉPARTEMENT AUTOMATIQUE
Language of instruction: ANGLAIS
Campus: CAMPUS DE PARIS - SACLAY
Workload (HEE): 60
On-site hours (HPE): 35,00
Elective Category : Engineering Sciences
Advanced level : Yes

Description

Industrial and service robotics currently undergo deep changes with the development of **collaborative robots designed to interact physically with humans**, and to share the same workspace or the same task. Collaborative robots are key elements both in **factories of the future** or in **assistance** tasks. Human-robot interaction is therefore an active research and development domain in robotics. It requires a **multidisciplinary** approach to design safe and efficient advanced systems.

Subjects covered by this course will allow the students to understand the main issues of interactive robotics and the technical aspects associated to these **complex systems in interaction with humans or their environment**. The course aims at exposing the context, the fundamental methodological tools and the current research and development subjects related to interactive robotic manipulators.

Quarter number

SG8

Prerequisites (in terms of CS courses)

- Automatic Control (ST5)
- Basic knowledge in rigid body mechanics to acquire by self-study if needed

Syllabus

- Introduction, brief historical perspective, industrial and research context
- Basics of modeling in robotics (geometric & kinematic models)

- Dynamic modeling (rigid and elastic body) and control of robots
- Force-feedback tele-operation
- Collaborative robotics
- Introduction to ROS (Robot Operating System)

Class components (lecture, labs, etc.)
Lectures, during which the presented concepts will be abundantly illustrated by examples, will be complemented with tutorial sessions on computers (in groups of two or three) to apply the theoretical concepts on practical case studies. The tutorials will require preparatory personal work outside class.

- **Tutorial #1 and Tutorial #2 :** illustration of robot modeling using Matlab/Simulink or python
- **Tutorial #3 and Tutorial #4:** introduction to ROS (Robot Operating Software) and application to robot manipulators

Class components:

- Lectures : 21h
- Tutorials on computers : 12h
- Final evaluation (quizz) : 2h

Grading
- Tutorials #1 & #2 : Written report following the tutorials with functional and commented programs [50% of overall grade];
- Final evaluation: written quizz with documents (2h) [50% of overall grade].
- Attendance checked during tutorials, possible penalty on the written report grade. An unjustified absence during a tutorial automatically leads to grade 0 for the said tutorial.

Course support, bibliography

- **Handouts :** Slides shown during the lectures

- **References :** W. Khalil, E. Dombre, “Modeling, Identification and Control of Robots”, Butterworth-Heinemann, 2004.

Resources

- **Teaching staff (instructor(s) names):** Maria Makarov, Mathieu Grossard (CEA LIST Laboratoire de Robotique Interactive), Franck Geffard (CEA LIST Laboratoire de Robotique Interactive), Xavier Lamy (CEA LIST Laboratoire de Robotique Interactive), Alex Caldas (ESME Sudria)

- **Maximum enrollment:** tutorial groups of max 18 students

- **Software**, number of licenses required:

    - Matlab/Simulink, campus license (unlimited)
    - python (free)
    - ROS (free; virtual machine provided with Ubuntu and ROS installed)

Learning outcomes covered on the course

After completion of this course, students will be able to:

- Describe the current context (through technical, applicative and economic issues) of interactive robotics seen as a multidisciplinary field related to the interaction between human and robot and between robot and environment. Describe the main hardware and software components of an industrial robotic system.
- Establish the classical models of a robot manipulator: geometric, kinematic, dynamic models.
- Select the appropriate control architecture depending on the target application and determine its tuning parameters in order to satisfy the performance-robustness trade-off.
- Model a robot manipulator in contact with a human or a passive environment; determine the stability conditions of the global feedback-controlled system (teleoperation or collaboration cases).
- Use specialised software (Matlab/Simulink or python, ROS) to build and simulate models of robot manipulators as dynamical systems.
- Master scientific and technical communication (through reports on the tutorials).

Description of the skills acquired at the end of the course

- “Establish the classical models of a robot manipulator: geometric, kinematic, dynamic models” and “Model a robot manipulator in contact with a human or a passive environment” is included in the skill C1.2 “Select, use and develop modelling scales, allowing for appropriate simplifying hypotheses to be formulated and applied towards tackling a problem” – milestone 3.

- “Select the appropriate control architecture depending on the target application and determine its tuning parameters in order to satisfy the performance-robustness trade-off” and “determine the stability conditions of the global feedback-controlled system (teleoperation or collaboration cases)” is included in the skill C1.1 "Examine a problem in full breadth and depth, within and beyond its immediate parameters, thus understanding it as a whole. This whole weaves the scientific, economic and social dimensions of the problem" and in C1.4 “Design, detail and corroborate a whole or part of a complex system” – milestone 2.

- “Use specialised software to build and simulate models of robot manipulators as dynamical systems” is included in the skill C6.1 “Identify and use the necessary software for one’s work” – milestone 1 and C1.3 "Apply problem-solving through approximation, simulation and experimentation " – milestone 3B

- "Master scientific and technical communication (through reports on tutorials)" is included in the skill C7.1 "Render complex content intelligible. Structure one’s ideas and arguments. Synthesize and see the bigger picture" – milestone 1