Master's Department of Engineering Sciences

MSc in Automation Engineering and Robotics

Name of the unit: Control of Robots in Physical Interaction with Humans

Lecturer: Mahdi Khoramshahi ()
Course code:
Student workload: 12 h of lectures, 2 h of tutorials, 4 h of labs
Credits: 3 ECTS
Specialization tracks: ☒ ROBOT (elective) ☐ SI ☒ MeDH (elective)
Semester offered: ☐ S1 ☐ S2 ☒ S3 ☐ S4
Language of instruction: ☐ French ☒ English
Targeted audience: ☒ Engineering Sciences students ☐ Other (specify):
Localization : ☒ PMC Campus ☐ Other (specify):

Course Overview

Collaborative robotics and physical human-robot interaction (pHRI), compliant control, shared autonomy and user-centered robotics.
Keywords: pHRI, impedance control, admittance control, shared control, shared autonomy, intention detection, collaborative robotics, human-aware planning, compliance, cobotics

Prerequisites

Students should have previously acquired the following prerequisites to follow this course:

- Modeling and dynamics of robotic manipulators
- Control of robotic systems (joint-space and task-space control)
- Fundamentals of linear algebra and dynamical systems
- Concepts of stability (Lyapunov)
- Programming (Python / MATLAB)
- Basic concepts of motion planning (optional)

Intended Learning Outcomes

By the end of this course, students will be able to:

1. Understand the challenges and applications of physical human-robot interaction
2. Identify safety constraints in collaborative robotics
3. Model physical interactions between humans and robots
4. Design an impedance controller
5. Design an admittance controller
6. Analyze the stability and passivity of systems in physical interaction
7. Implement a shared-control architecture
8. Understand and compare different intent-detection strategies
9. Integrate adaptation mechanisms into robot control
10. Analyze human-aware planning methods
11. Implement a simple collaborative-robot system in simulation
12. Present and analyze a scientific paper on interactive robotics

Indicative Teaching Sequence and Methods

Week	C/TD/TP*	Content	Preparation	Learn. outc.
S1	C1	Introduction to pHRI + safety	Read the handbook chapter	AAV1-2
S2	C2	Impedance control	Review robot dynamics	AAV3-4
S3	C3	Advanced admittance and compliance	Read the provided paper	AAV4-5
S4	TD	Impedance/admittance + stability	Analytical exercises	AAV4-6
S5	TP	Impedance implementation (Drake simulator)	Python requis	AAV4-6,11
S6	C4	Shared control	Read the provided paper	AAV7
S7	C5	Intent detection and adaptation	Read the provided paper	AAV8
S8	C6	Planning and AI for pHRI	Read the provided paper	AAV10
S9	Presentation - Papers	Student literature review: presentation of scientific papers in the field	Oral presentation	AAV2,6,8,10,12
S10	Project	Independent work (outside scheduled sessions)		AAV4-5,7,11
S11	Project	Independent work (outside scheduled sessions)		AAV4-5,7,11
S12	Presentation - Project	Demo + code		AAV4-5,7,11

* C/TD/TP respectively corresponds to lectures, tutorials and lab sessions.

Sequence of the unit:
Lectures introduce the fundamental concepts of physical human-robot interaction, followed by tutorials focused on modeling and stability analysis.
Practical sessions involve implementing impedance and interaction controllers in a simulated environment (Drake).
A two-person mini-project integrates the concepts covered in class through the development of an interactive system (compliant control or shared control).
A scientific-paper presentation completes the course by developing critical-analysis skills.

Indicative Assessment of Intended Learning Outcomes (1st session)

Week	Individ./group	In-person/remote	Type of exam	Evaluated outcomes	Scale %
S1-S9	Individual	In-person	Other		10 %
S5	Group	In-person	TP	AAV4-6,11	30 %
S9	Group	In-person	Other	AAV2,6,8,10,12	20 %
S12	Group	In-person	Other	AAV4-5,7,11	40 %

2nde session of exam

Session	Individ./group	In-person/remote	Type of exam	Evaluated outcomes	Scale %
2	Individual	In-person	Written exam	AAV 1-10	100 %

Bibliographic references

- Haddadin Croft, Physical Human-Robot Interaction, Springer Handbook of Robotics
- Hogan, Impedance Control: An Approach to Manipulation

Date of generation of this unit description: October 6, 2026