MICRO-462 **Learning and adaptive control for robots**

Cursus	Sem.	Type
Robotics	MA2, MA4	Opt.

Language of teaching	English
Credits	4
Session	Summer
Semester	Spring
Exam	Oral
Workload	120h
Weeks	14
Hours	**4 weekly**
Lecture	2 weekly
Exercises	2 weekly
Number of positions	

Remark

Pas donné en 2023-24. Cours donné tous les deux ans.

Summary

To cope with constant and unexpected changes in their environment, robots need to adapt their paths rapidly and appropriately without endangering humans. this course presents method to react within millisecunds.

Content

This course presents methods by which robots can learn control laws using machine learning. On-line reactivity is not just a matter of ensuring enough CPU on-board of the robot. It requires inherently robust control laws that can provide a multiplicity of solutions. In this course, we will see methods based on dynamical systems theory. Dynamical systems-based control law offer closed-form solution, hence with no need for further optimization at run time, and with convergence and stability guarantees. We will see applications of these methods for manipulation and navigation of robot arm manipulator and full body humanoid robots.
Topics include:

- Learning control laws with stability guarantees
- Synchronizing control laws and applications (multi-joint control, catching objects in flight)
- Modifying control laws for safe obstacle avoidance
- Learning force and impedance control for robust manipulation

Keywords

Robotics, Machine Learning, Nonlinear Control, Dynamical systems theory, Robust and Adaptive Path Planning for Manipulation and Navigation

Learning Prerequisites

Required courses

MICRO-452 Basics of Mobile Robotics
MICRO-455 - Applied Machine Learning

Recommended courses

COM-502 Dynamical system theory for engineers
ME-225 Dynamical systems
MATH-325 Dynamical systems and bifurcation

Important concepts to start the course

Nonlinear regression techniques and classification from machine learning: GMM/GMR, SVM/SVR, NN
Differential equation, fixed points analysis, theory of stability in linear and nonlinear dynamical systems

Learning Outcomes

By the end of the course, the student must be able to:

- Choose for learning robotic tasks
- Formalize stability of a learned controller
- Prove stability of a learned controller
- Transpose example of robotic application to another application

Transversal skills

- Use a work methodology appropriate to the task.

Teaching methods

The course will be composed of lectures and of exercises and practice sessions. The class presents the theory. In the exercise sessions, students will get to solve equations on paper but also to program the algorithms. Programming language will be matlab, but students who wants can use python.

Expected student activities

Students are expected to attend the exercise sessions and the computer-based practice sessions. They should revise the class notes prior to going to practical session to be on top of the the theoretical material prior to applying it. Students who are no longer up to date with the pre-requisites should work on these in parralel to taking the class.

Assessment methods

100% of the grade is based on an oral exam.

Supervision

Office hours	No
Assistants	Yes
Forum	Yes

Resources

Virtual desktop infrastructure (VDI)

No

Ressources en bibliothèque

- Learning for adaptive and reactive robot control a dynamical systems approach Aude Billard, Sina Mirrazavi, Nadia Figueroa

Notes/Handbook

Reference is the Book: ##Learning for Adaptive and Reactive Robot Control, MIT Press
https://mitpress.mit.edu/books/learning-adaptive-and-reactive-robot-control

Websites

- https://www.epfl.ch/labs/lasa/mit-press-book-learning/

Moodle Link

- https://go.epfl.ch/MICRO-462

Videos

- https://tube.switch.ch/channels/rm4h0JsXgI