

# PhD program in Civil, Chemical and Environmental Engineering

## Curriculum in Fluid Dynamics and Environmental Engineering

Academic year 2021/2022

### **1. Title of the course**

A tour of reinforcement learning and applications

### **2. Contents**

The goal of this course is to provide an introduction to reinforcement learning, striking a balance between mathematical formalism and the discussion of real world applications. Reinforcement learning treats general sequential decision problems, where an agent learns how to behave optimally by interacting with the environment. The agent aims at choosing actions that maximize a cumulative measure of future rewards. In the simplest instance of sequential decision making, the agent can leverage full knowledge of the environment. Starting from these classical problems in control of dynamical systems, we will gradually add layers of complexity by removing knowledge of the underlying dynamics that governs the system.

- We first discuss the foundations of dynamic programming to solve Markov Decision Processes with a finite horizon.
- We then extend the analysis to infinite horizon problems, derive the Bellman optimality equation and widely used algorithms to find optimal policies (value and policy iteration, Q learning).
- We treat the case where the underlying dynamical system is unknown (either the evolution rule, or the current state of the system or both).
- Finally, we discuss recent applications of reinforcement learning to biologically inspired navigation, where real agents interact with a complex environment to reach a desired location.

### **3. Structure of the course**

The course will consist of formal lectures and Python laboratories. A Python tutorial will be provided.

### **4. Lecturers**

Agnese Seminara and Alessandro Verri.

### **5. Duration and credits**

5 weeks, typically 6 hours per week, including 1 lab per week, 6 cfu

### **6. Period and registration procedure**

Mid May to mid June 2022. The course will be activated only if at least 5 students will be registered to participate.

## **7. Deadline for registration**

April 15<sup>th</sup>, 2022

## **8. Final exam**

The final exam will consist in a theoretical or computational project chosen by the students. At the end of the course the students will be asked to give a presentation.