Cursus Ingénieur Centralien

CentraleSupélec

Option Mathématiques Appliquées
2017-2018

Electif E ?, Majeure [Data, Finance, Modélisation Mathématique]

Titre : *Advanced Machine Learning (Reinforcement Learning & Information Theory)*

Enseignant responsable : Guillaume Charpiat, researcher at INRIA (TAU team)
Période : de début janvier 2017 à fin mars 2017
Lieu : campus de Saclay ?
Prérequis : mathematics (probabilities/statistics, linear algebra, differential calculus, analysis)
programming (python)

Description : Machine learning is at the core of many recent technological revolutions and is required to extract information from the large amounts of data that are now produced daily. Its applications are wide, from training robots how to walk, to clinical trials, advertisement suggestions, recognizing handwritten characters, playing Go, detecting spam... This course is the continuation of the course Foundations of Machine Learning and will cover the remaining main domains of machine learning, i.e. ***information theory*** and ***reinforcement learning***.

Contents :
Information theory is the mathematical foundation of machine learning: it is essential to understand its underlying concepts, and to model machine learning problems properly. We will see how the notions of prediction (what is likely to be the next character in this text?), generation (improvising new sentences) and compression (how to store losslessly large amounts of text as compactly as possible) are closely related, and what are the natural quantities to consider when considering distributions, in order to quantify the efficiency of machine learning algorithms.
Reinforcement learning is the part of machine learning dedicated to exploration strategies. In a given environment (a video game, clinical trials, robot moving in a gravitational field), given a set of possible actions (press this key, test this drug, move this articulation), what is the best sequence of actions to achieve the goal (winning the game, finding out the best drug, walking without falling) ?

Program :
0 - Introduction
Part A - Reinforcement Learning
1 - Bandits and Combination of Experts for time series prediction
2 - Learning dynamics (Bellman equation, Q-learning...)
3 - Monte Carlo Tree Search
Part B - Information Theory
4 - Entropy
5 - Compression/Prediction/Generation equivalence
6 - Kolmogorov complexity
7 - Information geometry (Fisher information)
Part C – Putting everything together
8 – Reinforcement Learning using Information Theory

Bibliography :
Reinforcement learning:
- Reinforcement Learning: An Introduction : Richard S. Sutton & Andrew G. Barto
- Statistical Learning and Sequential Prediction : Alexander Rakhlin & Karthik Sridharan

Information theory:

- Information theory, inference, and learning algorithms : David MacKay
- *Elements of information theory (2nd edition)* : Thomas Cover & Joy Thomas
- Notes by Jérémy Bensadon of courses by Yann Ollivier

Equipe pédagogique : TAU team, LRI / INRIA Saclay
Modalités d'évaluation : project + exercises
More information at https://www.lri.fr/~gcharpia/machinelearningcourse/ .