EE-559

# Deep learning

Cavallaro Andrea

| Cursus | Sem. | Type |
|---|---|---|
| Civil & Environmental Engineering | | Opt. |
| Computational science and Engineering | MA2, MA4 | Opt. |
| Computer science | MA2, MA4 | Opt. |
| Cybersecurity | MA2, MA4 | Opt. |
| Data Science | MA2, MA4 | Opt. |
| Data science minor | E | Opt. |
| Digital Humanities | MA2, MA4 | Opt. |
| Electrical Engineering | | Opt. |
| Electrical and Electronical Engineering | MA2, MA4 | Opt. |
| Financial engineering | MA2, MA4 | Opt. |
| Learning Sciences | | Opt. |
| Life Sciences Engineering | MA2, MA4 | Opt. |
| Minor in Quantum Science and Engineering | E | Opt. |
| Neuro-X minor | E | Opt. |
| Neuro-X | MA2, MA4 | Opt. |
| Quantum Science and Engineering | MA2, MA4 | Opt. |
| Robotics, Control and Intelligent Systems | | Opt. |
| Robotics | MA2, MA4 | Opt. |
| SC master EPFL | MA2, MA4 | Opt. |
| Statistics | MA2, MA4 | Opt. |

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|---|---|
| Language of teaching | English |
| Credits | 4 |
| Withdrawal | Unauthorized |
| Session | Summer |
| Semester | Spring |
| Exam | During the semester |
| Workload | 120h |
| Weeks | 14 |
| **Hours** | **4 weekly** |
| Lecture | 2 weekly |
| Exercises | 2 weekly |
| **Number of positions** | **150** |

## Summary

This course explores how to design reliable discriminative and generative neural networks, the ethics of data acquisition and model deployment, as well as modern multi-modal models.

## Content

This course equips students with a comprehensive foundation of modern deep learning, enabling students to design and train discriminative and generative neural networks for a wide range of tasks. Topics include:

- Deep learning applications (natural language processing, computer vision, audio processing, biology, robotics, science), principles and regulations
- Loss functions, data and labels, data provenance
- Training models: gradients and initialization
- Generalization and performance
- Transformers
- Graph neural networks
- Generative adversarial networks
- Variational autoencoders
- Diffusion models
- Multi-modal models
- Interpretability, explanations, bias and fairness

## Keywords

machine learning, neural networks, deep learning, python

## Learning Prerequisites

### Required courses

- Basics in probabilities and statistics
- Linear algebra
- Differential calculus
- Python programming

### Recommended courses

- Basics in optimization
- Basics in algorithmic
- Basics in signal processing

### Important concepts to start the course

Discrete and continuous distributions, normal density, law of large numbers, conditional probabilities, Bayes, PCA, vector, matrix operations, Euclidean spaces, Jacobian, Hessian, chain rule, notion of minima, gradient descent, computational costs, Fourier transform, convolution.

## Learning Outcomes

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

- Interpret the performance of a deep learning model
- Analyze the limitations of a deep learning model
- Justify the choices for training and testing a deep learning model
- Propose new solutions for a given application

## Transversal skills

- Respect relevant legal guidelines and ethical codes for the profession.
- Take account of the social and human dimensions of the engineering profession.
- Design and present a poster.
- Make an oral presentation.
- Demonstrate the capacity for critical thinking

## Teaching methods

Ex-cathedra lectures, class discussion, exercises (using python), group project.

## Expected student activities

Attendance to lectures, participation in discussions, completing exercises, completing a project, reading written material (scientific papers and books).

## Assessment methods

Excercises and group project.

## Resources

### Moodle Link

- https://go.epfl.ch/EE-559