Last update: 30-06-2017

230584 - ML - Machine Learning on Classical and Quantum Data

Coordinating unit: 230 - ETSETB - Barcelona School of Telecommunications Engineering

Teaching unit: 739 - TSC - Department of Signal Theory and Communications

Academic year: 2017

Degree: ERASMUS MUNDUS MASTER'S DEGREE IN PHOTONICS ENGINEERING, NANOPHOTONICS AND BIOPHOTONICS (Syllabus 2010). (Teaching unit Optional)
MASTER'S DEGREE IN PHOTONICS (Syllabus 2013). (Teaching unit Optional)

ECTS credits: 3 Teaching languages: English

Teaching staff

Coordinator: Peter Wittek

Others: Peter Wittek

Teaching methodology

- Lectures
- Activities: - Practicals on machine learning algorithms and quantum simulations
  - Seminars

Learning objectives of the subject

Machine learning is becoming an indispensable life skill with countless applications in any field where data is available. In this course, we will study the state-of-the-art methods in shallow architectures such as random forests and XGBoost, and also in deep learning, including feedforward convolutional neural networks and recurrent networks. We will put a strong emphasis on hands-on training on real-life problems. We will discuss the major learning paradigms (supervised, unsupervised, generative, and reinforcement learning) as well as the main types of data (structured, semi-structured, an unstructured).

The pace of development in quantum technologies is akin to the rapid advances made in machine learning. It is natural to ask whether quantum resources could boost learning algorithms: this field of enquiry is called quantum-enhanced machine learning. Recent progress indicates that current and near-future quantum technologies have tangible benefits for machine learning. The second half of the course will focus on these methods, demonstrating the difficulty of the problems by classical simulations.

Study load

Total learning time: 95h 15m	Hours large group:	22h 30m	23.62%
	Hours medium group:	0h	0.00%
	Hours small group:	22h 30m	23.62%
	Guided activities:	0h	0.00%
	Self study:	50h 15m	52.76%

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Content

Part 1: Machine learning on classical data

Learning time: 14h 30m

Theory classes: 7h 30m
Guided activities: 7h

Description:

1. Introduction to machine learning. What makes a good hypothesis and the problem of generalization. Shallow architectures and feature engineering.
2. Deep learning. Feedforward neural networks, convolutional layers. Image classification.
3. Deep learning with recurrent neural networks. Long short-term memory and text generation.
4. Unsupervised learning and manifold embedding. Debugging neural networks.
5. Reinforcement learning.

Part 2: Quantum-enhanced machine learning

Learning time: 8h

Theory classes: 4h
Guided activities: 4h

Description:

1. Thermal state sampling protocols and probabilistic methods.
2. Discrete optimization on quantum hardware.
3. Coherent quantum protocols.

Qualification system

- Homework assessments (50%)
- Written exam (35%)
- Oral presentation of a scientific journal paper (15%)

Bibliography

Basic:

Hastie, T.; Tibshirani, R. & Friedman, J.. The Elements of statistical learning: data mining, inference, and prediction [on line]. New York: Springer, 2009 [Consultation: 10/07/2017]. Available on: <http://dx.doi.org/10.1007/978-0-387-84858-7>. ISBN 9780387848570.

Murphy, K. P. Machine learning: a probabilistic perspective. Cambridge. MA: MIT Press, 2012. ISBN 9780262018029.

Wittek, P.. Quantum machine learning: what quantum computing means to data mining. Elsevier, 2016. ISBN 9780128100400.