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, and 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.

### 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, and unstructured).

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### Study load

<table>
<thead>
<tr>
<th>Total learning time: 75h</th>
<th>Hours large group:</th>
<th>Hours small group:</th>
<th>Self study:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>22h 30m</td>
<td>2h 15m</td>
<td>50h 15m</td>
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<tr>
<td></td>
<td>30.00%</td>
<td>3.00%</td>
<td>67.00%</td>
</tr>
</tbody>
</table>
230584 - ML - Machine Learning on Classical and Quantum Data

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.
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.

Qualification system

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

Bibliography

Basic:
