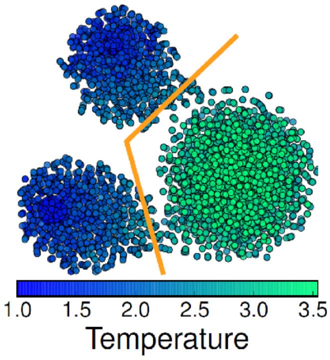
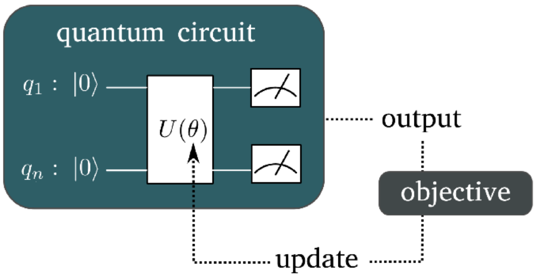
Quantum Machine Learning in a nutshell





Lectures by Oleksandr Kyriienko

Course description: In this express-course I will provide the state-of-the-art knowledge in the field of machine learning (ML) interfaced with a quantum information paradigm. Various facets of the subjects will be touched, including quantum inspired machine learning algorithms, modern applications of ML in condensed matter and chemistry, as well as full fledged quantum machine learning developments.

The course is divided into 8 lectures (~2 academic hours each) and 2 seminars, and is intended to be run over 2 weeks period. The lectures will be supplemented with a homework, structured in the form of coding tasks or contemporary literature analysis. After the course, the examination will be performed in the passed/not-passed form.

Course structure:

Lecture 1: Introduction to Quantum Machine Learning
Classification of quantum ML tasks and applications. Introduction to classical machine learning and its quantum applications. Machine learning with quantum hardware and classical algorithms. ML-inspired quantum computing. Quantum algorithms overview for future quantum computers.

Lecture 2: Quantum Matter Classification with Machine Learning (part 1)
Phase transition detection from Quantum Monte Carlo. Application of supervised and unsupervised methods for the detection. Refined phase boundaries with recurrent neural nets and deep learning.

Lecture 3: Quantum Matter Classification with Machine Learning (part 2)
Detection of topological states with machine learning techniques. Real space topological feature extraction in disordered media. Unsupervised topological number detection. Entanglement characterization with ML.

Lecture 4: Machine learning-inspired quantum protocols
Restricted Boltzmann machines (RBM) and new ansatzes for ground state search problems. Detection of phase transitions with RBMs. Relation to tensor network methods.

Lecture 5: Reinforcement learning for quantum applications
Improved error correction using reinforcement learning (RL) techniques. Q-learning. Designing quantum experiments with RL and search for new quantum circuits. RL-based search for short-cut annealing strategies.

Lecture 6: Genuine quantum machine learning (part 1)
Introduction to gate-based quantum computation (QC). Recent advances in QC area, for both hardware and software. Variational quantum computing. Linear algebra quantum algorithms and relation to machine learning.

Lecture 7: Genuine quantum machine learning (part 2)
Quantum Random Access Memory. Quantum Principal Component Analysis. Quantum K-Means and K-Medians. Quantum Hierarchical Clustering.

Lecture 8: Genuine quantum machine learning (part 3)
Quantum Classification with Support Vector Machines. Variational Quantum Autoencoder. QBoost. Open problems of Quantum Machine Learning (Input, Output, Costing, and Benchmarking problems). Perspectives.