Course title: Quantum machine learning

Course code: 63546I

ECTS: 6

Professor: Bojan Žunkovič

Undergraduate/ <u>master program</u>

Prerequisite knowledge:

- Linear algebra: vector spaces, basis, dimension, linear maps, matrix representation, rank, singular value decomposition, Hilbert spaces
- Basic machine learning: boosting, supervised/unsupervised ML, kernel methods, representer theorem
- Basic probability theory

Short course description:

- Introduction to quantum machine learning, historical context, and basic concepts of classical probability and information theory.
- Basics of quantum probability and information, including superposition, quantum probability functionals, and entanglement.
- Introduction to multi-particle quantum systems, quantum computing models, and hardware approaches (SQUID, ultra-cold ions, optical systems).
- Quantum gate computing model, teleportation, and adiabatic quantum computing.
- Quantum Fourier Transform (qFT) and the phase estimation algorithm.
- qFT-based quantum algorithms, matrix inversion, qBLAS, and basic quantum algorithms for machine learning.
- Grover's search algorithm .
- Quantum data encoding, quantum optimization, and adiabatic computation simulation with quantum gates.
- Sampling from thermal distributions, hybrid quantum-classical algorithms, and variational quantum algorithms.
- Quantum versions of classical algorithms, supervised learning on quantum devices, and quantum ensembles with QBoost.
- Quantum algorithms for unsupervised learning, including quantum K-means and probabilistic graphical models.
- Exploration of quantum kernel methods.
- Tensor networks for simulating multi-particle quantum systems and their applications in machine learning.
- Techniques derived from quantum mechanics applied to classical computing problems, focusing on recommendation systems.
- Quantum neural states and their use in approximating highly entangled quantum states.