Quantum Computing for NP-Hard Problems and Artificial Intelligence

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ABSTRACT

Quantum Artificial Intelligence (QAI) refers to the utilization of quantum computing to tackle computationally challenging problems in the domain of AI. Unlike classical computation, quantum computing operates based on the principles of quantum mechanics, which encompass the superposition, interference, and entanglement of quantum states of particles. While interpretations of quantum mechanics may vary, there is consensus regarding the mathematical framework and practical application of quantum mechanical principles in computation.

This course takes a computer science perspective on QAI and is structured into three main parts. The first part provides a concise introduction to the fundamental concepts of gate-based and adiabatic quantum computational models. The second part showcases various hybrid quantum-classical algorithms that can be employed in application domains with particular focus on machine learning and combinatorial optimization. Lastly, the course explores the feasibility and potential benefits of employing quantum computational methods to address specific AI problems. Special emphasis is given to the feasibility and the advantages of quantum AI solutions with respect to their classical counterparts, demonstrating practical applications of quantum computation in real-world scenarios.

COURSE INFORMATION

Duration: 15 Hours
Lecture format: 3 hour-long hybrid lectures
Period: From 3rd – 11th October 2023
Expression of interest: Please fill this Google Form to participate
Location: Viale Risorgimento 2, Room TBD

PREREQUISITES

The course is intended for PhD students with basic knowledge of linear algebra, machine learning, combinatorial optimization and complexity theory. Prior knowledge of quantum mechanics and/or quantum computing is not required.

PROGRAM

Lecture 1: Introduction to Quantum Computing: basic concepts and algorithms

Lecture 2: Hybrid quantum-classical computing: variational quantum algorithms

Lecture 3: Quantum Machine Learning: quantum algorithms for supervised and reinforcement learning

Lecture 4: Tackling NP-Hard combinatorial optimization problems using quantum approaches: QAOA and quantum annealing

Lecture 5: Quantum AI algorithms: planning and scheduling, coalition formation in multi-agent system, machine learning

EXAM

To obtain certification for your course participation through an exam, you have the following two options available. To submit your exam, please get in touch with me via email.

Report Students are required to submit a report (2-3 pages excluding references) that briefly describes the main challenges of a topic of interest and explores the potential benefits of quantum computing in addressing these challenges.

Presentation Approximately 1-2 weeks after the course concludes, each student will have the opportunity to give a presentation discussing the relevance and potential impact of quantum computing in a specific research area of interest. This area will be decided beforehand through mutual agreement between the lecturer and the student.