TIME TABLE

TIME	Monday	Tuesday	Wednesday	Thursday
	May 29	May 30	May 31	June 1
09.00 - 09.45	Registration	Lubasch	Supanut	Holmes
09.45 - 10.30	Cremonesi	Lubasch	Supanut	Holmes
11.00 - 11.45	Cremonesi	Lubasch	Supanut	Holmes
11.45 - 12.30	Cremonesi	Lubasch	Supanut	Holmes
14.00 - 14.45	Incudini	Mazzola	Innocenti	Ijaz
14.45 - 15.30	Ha Quang	Mazzola	Innocenti	Ijaz
16.00 - 16.45	Ha Quang	Poster Session	Incudini	Ijaz
16.45 - 17.30	Ha Quang	Poster Session	Incudini	Dicussion and closing
18.00	Welcome aperitif			

ADMISSION AND ACCOMMODATION

The course is offered in a hybrid format giving the possibility to attend the course also by remote (on Microsoft Teams platform).

On-site places are limited and assigned on first come first served basis.

The registration fees are:

- **On-site participation, 450.00 Euro + VAT***
This fee includes a complimentary bag, five fixed menu buffet lunches, coffee breaks, downloadable lecture notes.
Deadline for on-site application is **April 29, 2023**.

- **Online participation, 300.00 Euro + VAT***
This fee includes downloadable lecture notes.
Deadline for online application is **May 15, 2023**.

Course application is available at
https://www.cism.it/en/activities/courses/J2302/
A message of confirmation will be sent to accepted participants.

Upon request a limited number of on-site participants can be accommodated at CISM Guest House at the price of 35 Euro per person/night (mail to: foresteria@cism.it).

** where applicable (bank charges are not included)*
Italian VAT is 22%.

CANCELLATION POLICY

Applicants may cancel their registration and receive a full refund by notifying CISM Secretariat in writing (by email) no later than:
- April 29, 2023 for on-site participants (no refund after the deadline);
- May 15, 2023 for online participants (no refund after the deadline).
Cancellation requests received before these deadlines will be charged a 50.00 Euro handling fee. Incorrect payments are subject to Euro 50,00 handling fee.

For further information please contact:

CISM (*seat of the School)*
Palazzo del Torso - Piazza Garibaldi 18 - 33100 Udine (Italy)
tel. +39 0432 248511 (6 lines)
e-mail: cism@cism.it | www.cism.it
Information available also at **http://eqai.eu/**

ACADEMIC YEAR 2023

University of Udine
International Centre for Mechanical Sciences

Centro Internazionale
di Scienze Meccaniche
International Centre
for Mechanical Sciences

UNIVERSITÀ DEGLI STUDI DI UDINE
hic sunt futura

EQAI 2023
2nd European Summer School on Quantum AI

QUANTUM MACHINE AND DEEP LEARNING

FINAL PROGRAMME

CISM-UniUD Joint Advanced School
coordinated by

Giuseppe Serra
University of Udine, Italy

Alessandra di Pierro
University of Verona, Italy

Carla Piazza
University of Udine, Italy

Francesco Petruccione
University of KwaZulu-Natal, Republic of South Africa

Udine *May 29 - June 1* 2023

EQAI 2023 - QUANTUM MACHINE AND DEEP LEARNING

INVITED LECTURERS

Paolo Cremonesi - Polytechnic University of Milan, Italy

A Gentle Introduction to Quantum Computing
The lecture introduces the basic concepts of quantum computing to a non-specialist audience. No prior knowledge of quantum mechanics will be assumed. We will start by introducing the two main architectures: quantum annealing and universal quantum gate model. Then, we will introduce the qubit and study its properties. Finally, we will look into simple algorithms.

Zoe Holmes - EPFL, Lausanne, Switzerland

Hybrid variational quantum algorithms: how to make them work
After recapping the basic idea behind variational quantum algorithms we will spell out some ingredients to make them work. These include the choice in cost function, expressibility and trainability. The latter we will focus on, introducing barren plateau phenomenon and exploring its causes.

Aroosa Ijaz - University of Waterloo - Toronto, Canada

Machine learning with quantum software
In this introductory tutorial, we will explore how various quantum softwares are set up and how to code quantum machine learning models in them. More specifically, we will look at Pennylane and Tensorflow quantum in detail. For both softwares, we will explore their underlying structure, how data is embedded into quantum states, how variational quantum models are setup, how optimization and gradient routines are carried out and how machine learning problems can be expressed using quantum learning models.

Luca Innocenti - University of Palermo, Italy

Introduction to quantum reservoir computing
Quantum reservoir computing is a quantum machine learning protocol that shows great promise for implementation in the near future using state-of-the-art technologies, and its simplicity allows it to be implemented across a broad range of experimental scenarios. The basic principle involves utilizing a complex, untrained evolution to scramble input data in such a way that target functions become more accessible in the readout stage. We will delve into the intricacies that arise when translating classical reservoir computing schemes to the quantum domain, together with potential solutions and future prospects.

Guglielmo Mazzola - University of Zurich, Switzerland

Thresholds for quantum advantage in sampling and optimization
Sampling and optimization are anticipated applications of quantum computers. In this lecture, I will introduce new algorithms for sampling and re-visit established ones under a practical perspective, i.e. considering the effect of the unavoidable quantum measurements noise or taking into account the gate frequency constraint in the future fault-tolerant regime.
As a pedagogical example, I will discuss cases of end-to-end quantum resource estimates in the realm of quantum finance, where one is especially interested in assessing the runtime to solve a typical, concrete problem, beyond traditional asymptotic scaling assessments.

Minh Ha Quang - RIKEN Center for Advanced Intelligence Project, Tokyo, Japan

An introduction to Kernel Methods and Deep Neural Networks
This lecture will give an introduction to the fundamental concepts and algorithms at the core of two major paradigms in Machine Learning, namely Kernel Methods and Deep Neural Networks (DNNs). In the first part, we will discuss the basic concepts and algorithms in Kernel Methods, including positive definite kernels, feature maps, the associated reproducing kernel Hilbert spaces (RKHS), Support Vector Machine, and approximate methods such as the random Fourier features.Basic concepts of Statistical Learning Theory will be covered, including generalization error and VC dimension, which lead to fully rigorous theoretical justifications for algorithms in this setting. In the second part, we will discuss basic concepts from DNNs, including the most common architectures and training algorithms, as well as some of the recent theoretical results on their mathematical foundations. We will also discuss the connection between the two paradigms of DNNs and Kernel Methods via the neural tangent kernel.

Thanasilp Supanut - Centre for Quantum Technologies, National University of Singapore

Introduction to kernel methods in quantum machine learning
This lecture delves into the concept of quantum kernels and their application in machine learning. By leveraging the principles of quantum mechanics, quantum kernels allow for the efficient and accurate handling of high-dimensional data sets. We will explore the mathematical foundations of quantum kernels and their potential applications in improving the performance of various machine learning algorithms, as well as their limitations. Additionally, we will discuss the current state of research in this field and the potential for quantum kernels to play a significant role in the future of machine learning.

Michael Lubash - Cambridge Quantum Computing Ltd, UK

Introduction to quantum algorithms for differential equations
For the solution of differential equations, quantum computers have an exponential advantage over classical computers. This lecture addresses the questions where does this quantum advantage come from and how can we make use of it using current and future quantum computers. With respect to current quantum devices, useful machine learning-related techniques are presented for solving differential equations on noisy quantum hardware.

Massimiliano Incudini - University of Verona, Italy

Introduction to the Qiskit Framework and its Application in Machine Learning
We will introduce Qiskit as the software of choice for programming quantum computers. Qiskit is a powerful platform that empowers users to define and create quantum circuits that can be utilized for machine learning and optimization purposes. With Qiskit, users can define and create quantum circuits that are tailored to their needs and can be utilized for a variety of applications, including machine learning and optimization. As we move forward in the subsequent lectures, Qiskit will be an essential tool that we will rely on to explore the power of quantum computing. Its extensive documentation and sample codes make it an ideal companion that will enable you to grasp the concepts and techniques of quantum computing with ease. We will also explore how Qiskit can be utilized to implement machine learning pipelines based on quantum kernel technique.

LECTURES

All lectures will be given in English. Lecture notes can be downloaded from the CISM web site. Instructions will be sent to accepted participants.

LOCAL COMMITTEE

Alex Falcon - Post-doc Researcher, University of Udine
Beatrice Portelli - PhD Student, University of Udine
Riccardo Romanello - PhD Student, University of Udine
Simone Scaboro - Graduate Research Fellow, University of Udine