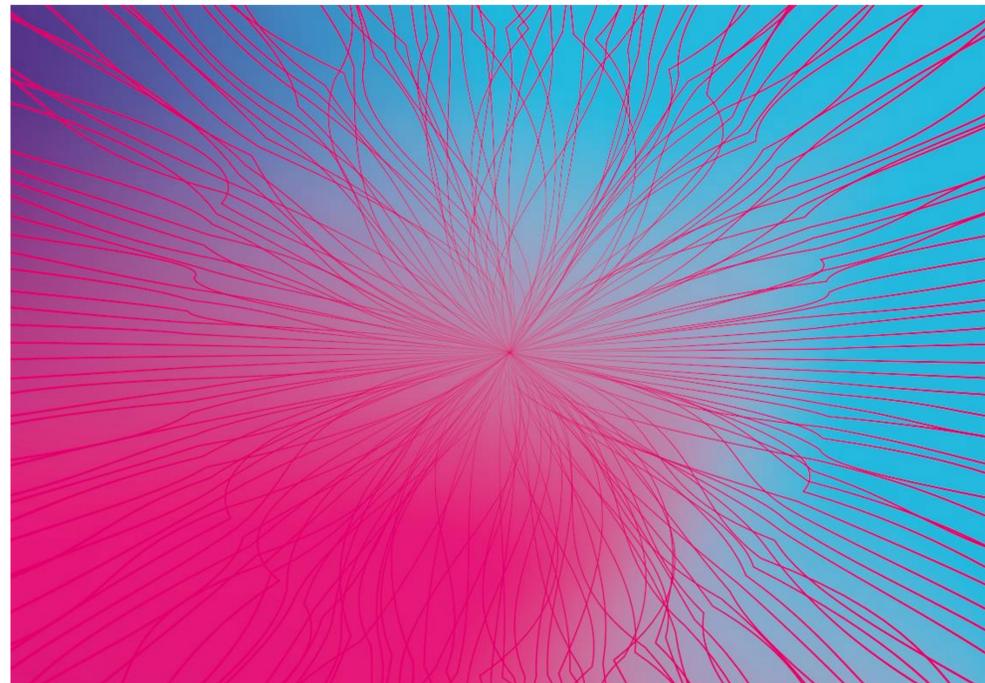


Quant²AI

Quantifying the benefits of quantum AI systems

The objective of this project is to provide a complete end-to-end pipeline for quantum machine learning (QML). Our goal is to identify datasets, methods or metrics where a quantum advantage is present and compare them to classical methods by developing a demonstrator and standardizing the QML process.

- Quantum Machine Learning
- Software Demonstrator
- Quantum Advantages
- Benchmarking
- Comparability with classical Machine Learning



Motivation

During past years the performance of quantum computers has increased drastically. It is common to read in the literature claims about quantum superiority and quantum advantages in the context of quantum computations. These claims raise expectations for developing and implementing complex AI algorithms on quantum hardware, and for evaluating how advantages can be realized.

The search for quantum advantages has reached also the fast developing field of Machine Learning (ML), where the concept of efficiency deals with multiple and subtle aspects of the tasks involved. Can such a complex framework be replicated using quantum hardware? Given sub-algorithms that have been proven to have quantum advantage on quantum hardware, are those advantages preserved when considering the overall ML system?

Realistic assessment of quantum advantages must take into account the complete ML process. Therefore a demonstrator that considers all relevant steps of the process is needed.

Status of Quantum Machine Learning

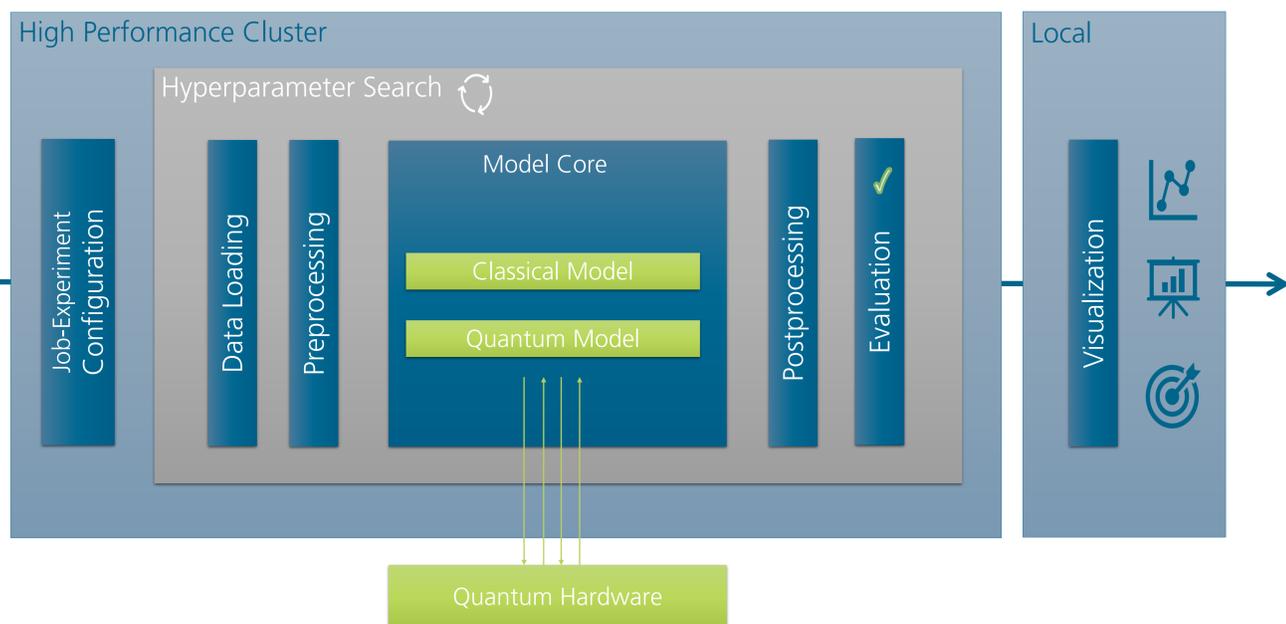
The field of Machine Learning is currently going through an exploration phase. There are many proposals for QML architectures that have been published, whose features are difficult to compare. This happens mainly due to:

- Inconsistent assessment standards
- Small abstract and scaled tasks
- Large difference in use cases
- Little focus on representativeness
- Focus on individual steps in the overall process

Project goals and achievements

Quant²AI should provide the framework to create a capability matrix for the complete QML pipeline based on a set of tasks and associated data. This framework should be based on the modular construction of the pipeline that will enable comparison of individual components. Key aspects that have been achieved are:

- *Modular behavior*: ML steps are well defined and separate.



- *Reproducibility*: Output folders are properly created with full information on experiments. Metainformation about the cluster and hyperparameters are included. The framework ensures clean and well defined environments for each of the steps.
- *Visualization*: The visualization tool performs filtering of experiments with defined desired features and does the relevant aggregation across them. It shows metric and hyperparameters by choosing a custom X and Y axis.
- *Comparability*: Modularity serves to define new experiments with clearly defined differences in their stages. Performance evaluation can be exported and fairly compared.
- *Significance*: Proper methods for statistical evaluation and comparison have been defined. It includes confidence intervals and performance profiling.
- *Extensibility*: The software is conceived in a way that provides spacious possibilities for extension of QML methods and evaluation metrics for users and researchers; given the fast development of the field.

- *Relevance*: use cases and problems with application relevance for DLR have been identified.
- Other aspects achieved in the project are:
- Main execution environment is an HPC cluster.
 - Quantum Hardware connection has been achieved. Quantum simulations are also part of its core functionality.
 - Large set of datasets: Both toy and real-world examples with (Q)ML models, pipeline modules and metrics.
 - Development of a framework to execute hyperparameter search, based on the evaluation step.
 - Provision of extensive documentation for further developing and a workshop to get familiarized with the software.

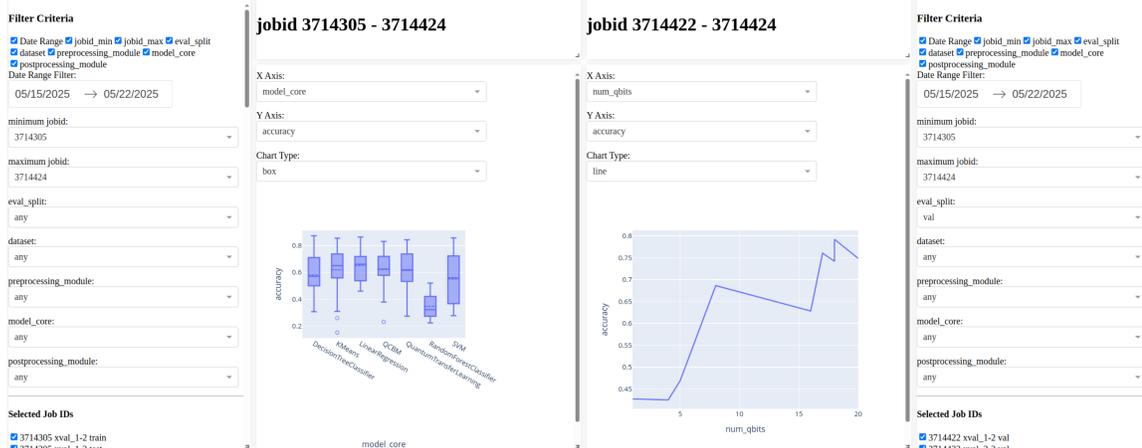
With these features this benchmarking software has the final objective of bridging the gap between heuristic ML applied on a research environment and real-world scenarios, with clear and well argued evaluation results.

The Industry Partner in Quant²AI

- Provides industry perspective on relevant AI applications and evaluation aspects of the benchmark
- Prepares problem examples and datasets for the benchmark.
- Develops a visualization tool.
- Implements a modular demonstrator that integrates all aspects of the pipeline and evaluate its performance.
- Participates in the application testing and the utilization of the results.



You can find more information of the project in our webpage



A project of



Contractor



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Get in touch.
We enable quantum!

