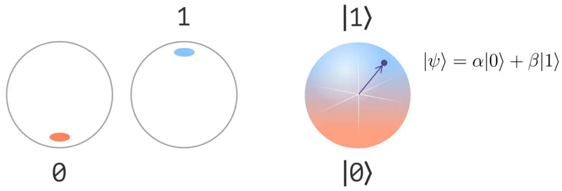
Hybrid Methods for Unsupervised Quantum Artificial Intelligence

Alessandro Poggiali, University of Pisa

Quantum Computing

Bit | Qubit



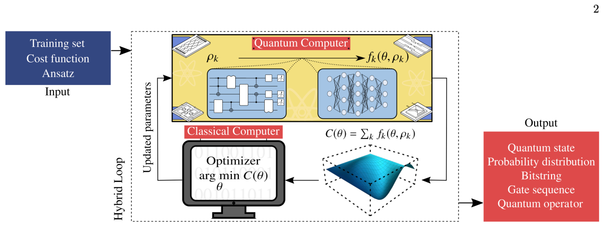
Leverage quantum mechanical properties to enhance classical computation

Superposition | **Entanglement** | **Interference**

Quantum Artificial Intelligence

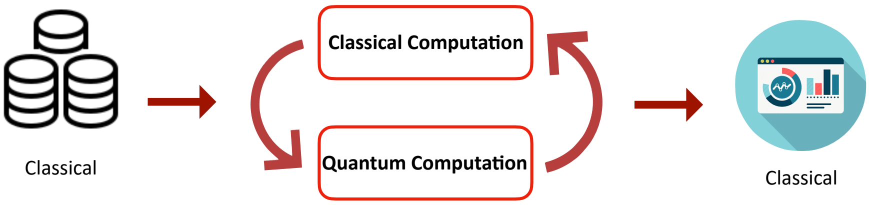
Goal of **QAI**:

1. Speed up computation of classical AI algorithms
2. Improve classical machine learning tasks
3. Enhance optimization techniques



Cerezo et al. Variational quantum algorithms. Nature Reviews Physics, 2021

Hybrid methods are the most suitable for current quantum hardware

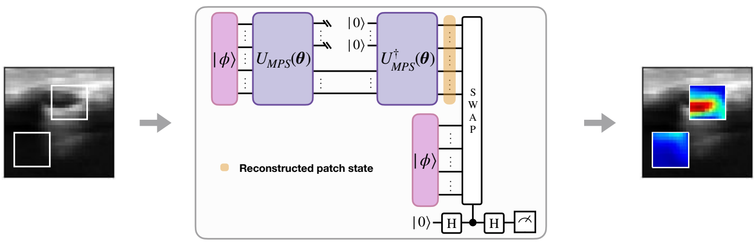


Quantum Clustering [1],[2]

Three hybrid quantum k-means algorithms exploiting different degrees of parallelism:

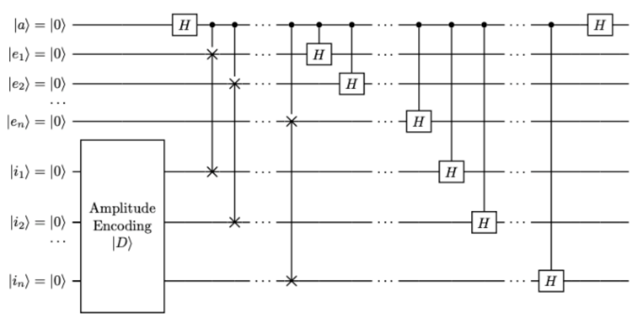
1. **q-k-means-q1** quantizes the single distance computation between a centroid and a record
2. **q-k-means-q2** computes in parallel the distances between a record and all centroids
3. **q-k-means-q3** computes simultaneously the distances between all records and all centroids

Quantum Autoencoder for Anomaly Segmentation [5]



VQA-based model exploiting quantum expressibility to enhance learning capabilities

Quantum Feature Selection and Outlier Detection [3],[4]

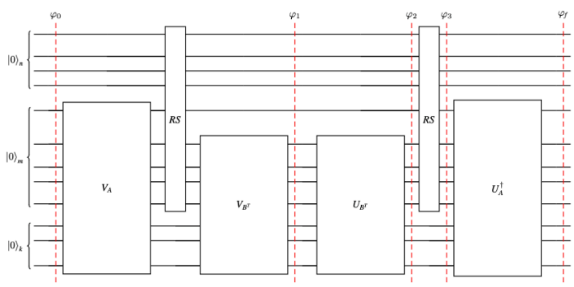


QVAR: quantum algorithm for estimating the variance of N real data in $O(\log N)$ quantum steps

Two QVAR-based algorithm:

- Hybrid Quantum Feature Selection (**HQFS**)
- Quantum Outlier Detection Algorithm (**QODA**)

Quantum Subroutine for Matrix Multiplication [6]



QMM: exponentially faster quantum subroutine for matrix multiplication

References

[1] Poggiali, A. et. al. (2022). Clustering Classical Data with Quantum k-Means. In *ICTCS* (pp. 188-200).
[2] Poggiali, A. et. al. (2024). Quantum clustering with k-means: A hybrid approach. *Theoretical Computer Science, 992*
[3] Poggiali, A. et. al. (2023). Quantum feature selection with variance estimation. In *Proceedings of ESANN.*
[4] Bernasconi, A. et. al.(2024). A. Quantum Subroutine for Variance Estimation: Algorithmic Design and Applications; *Quantum Machine Intelligence*
[5]Madeira, M. et. al. (2024). Quantum Patch-Based Autoencoder for Anomaly Segmentation. *In Proceedings of QCE*.
[6]Bernasconi, A. et. (2024). Quantum Subroutine for Efficient Matrix Multiplication. *IEEE Access*.