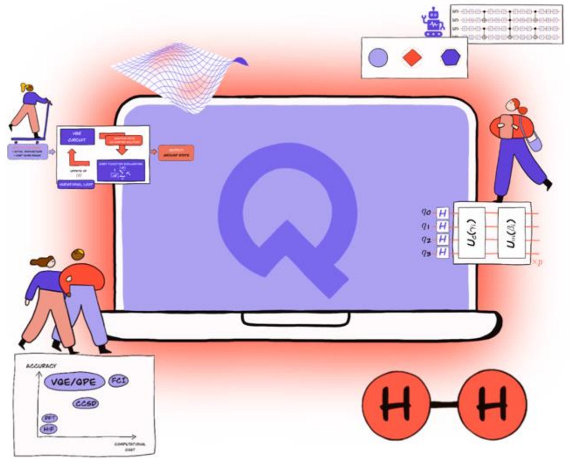
QUANDELA

Driven by quantum,
Empowered by Quandela

www.quandela.com



What we cover today

Quantum Advantage

- Quantum Advantage and Quantum Value

Quantum Algorithms

- Gate-based Algorithms
- Photonic Native Algorithms

Quantum Use Cases

- Battery Design
- Image Generation
- Molecular Docking
- Quantum Machine Learning

01.

Quantum Advantage

Quantum Advantage and Quantum Value

Advantage

A quantum advantage is obtained if a quantum computer can solve a given task **faster**, **more precise** or with **less energy** than the best classical solution.

Value

Quantum value is obtained if a quantum computer is used to solve a **practical relevant problem** while providing an **advantage over available classical solutions**.

State of the Technology

Photonic

Advantage:

Zhong H-S et al 2020

Madsen L S et al 2022

Google 2019 and 2024

Munoz-Bauza H et al 2025

Value:

None so far

02.

Quantum Algorithms

Gate based Quantum Algorithms

QUADRATIC ADVATAGE

EXPONETIAL ADVANTAGE

1982

QUANTUM SIMULATION
- → Drug design
- → Catalyst design
- → New materials, solar panels, electric batteries

1994

FACTORISATION
- → RSA decryption

1996

NON-STRUCTURE RESEARCH PROBLEM
- → Travelling salesman
- → Multi-agent pathfinding

2000

QUANTUM RANDOM WALKS
- → Graph search

2008

LINEAR EQUATIONS
- → Structural mechanics

2015

MONTE-CARLO
- → Option pricing
- → CFD simulation (fluid flow)

2016

FINITE ELEMENTS, SEMI-DEFINITE PROGRAMMING
- → CFD simulation
- → Structural mechanics

2020

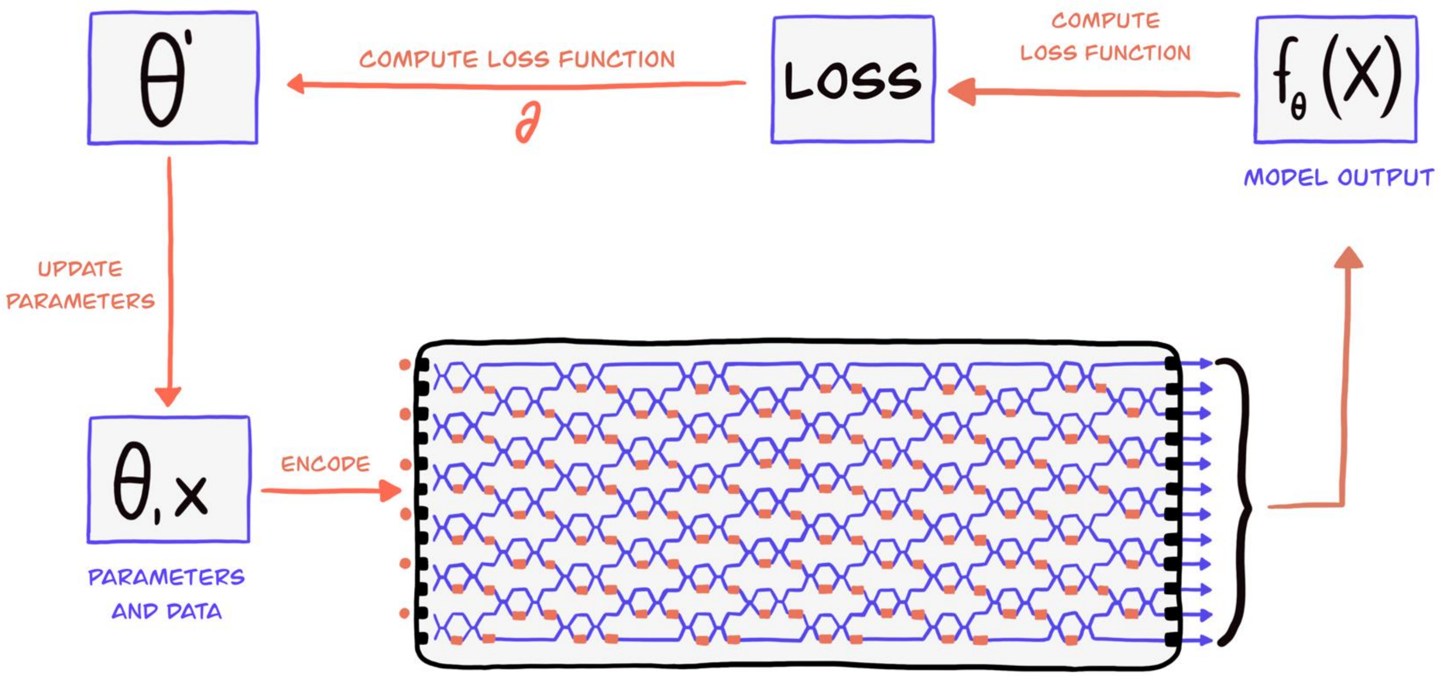
BRANCH AND BOUND
- → Schedule optimisation

2022

UNSUPERVISED LEARNING
- → Autonomous vehicles
- → People identification
- → Anomaly detection

Photonic Native Quantum Algorithms

- Quantum Machine Learning
- Graph based algorithms
- Photonic Reservoirs
- Cryptography



02.

Use-cases

Battery design

Challenges when designing a Battery

- Understanding the interface of electrodes and electrolytes.
- Predicting the properties of novel electrode materials.
- Predict lifetime and capacity of the battery.
- Simulation of the full battery.
- Finding chemical compounds for new battery designs.

Mathematical Problems to solve

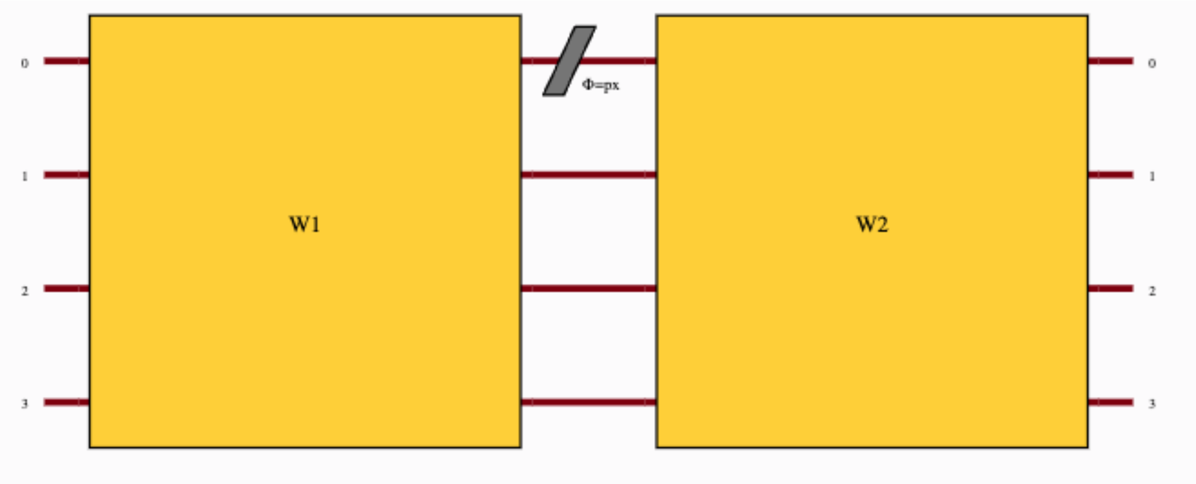
- Partial Differential Equations (PDEs)
- Electronic Structure Problem
- Optimisation
- Stochastic processes
- Machine learning

Battery design

Understanding the interface of electrodes and electrolytes.

Predicting the **lithium-oxide layer accumulation** by solving a **partial differential equation (PDE)**.

Photonic Variational Differential Equation Solver



The phase shifter encodes the data, and the unitary matrices are trained to find the solution of the differential equation.

Image Generation from Day to Night

Challenges when generating images

- Generalising to novel instances.
- Dealing with high-dimensional data.
- Hallucinating wrong details.
- Working with limited training data.

Mathematical Problems to solve

- Avoid overfitting
- Dimensionality reduction
- Maximum likelihood problem
- Sample complexity

AUTOMOTIVE AND AEROSPACE

Image Generation from Day to Night

Generalising to novel instances.

Generating night images by training the model on daytime images.

Photonic Enhanced Generative Model

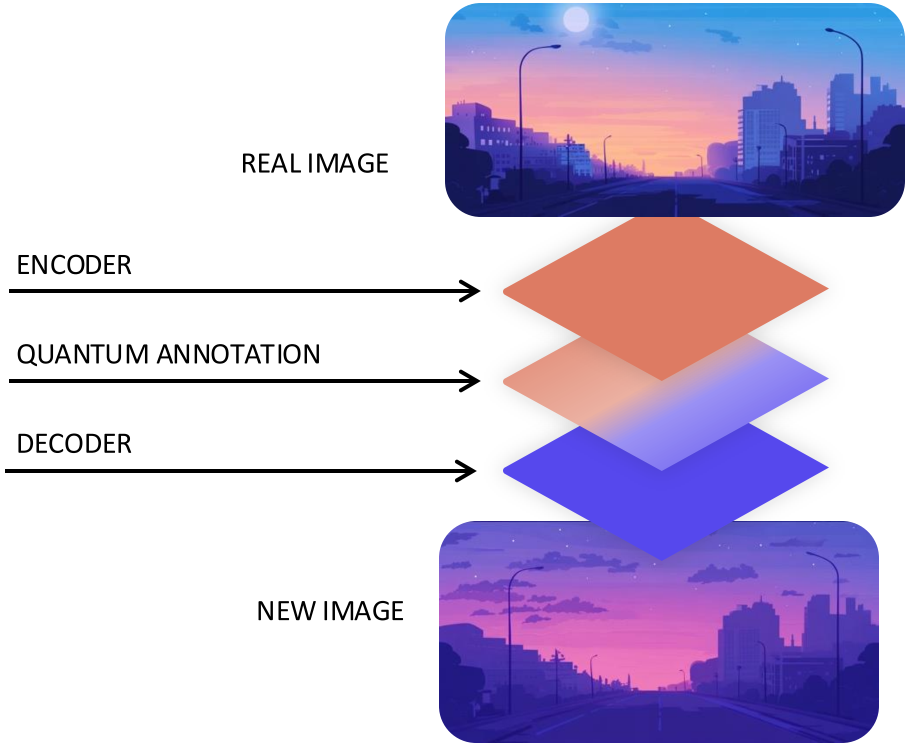


Image Generation from Day to Night

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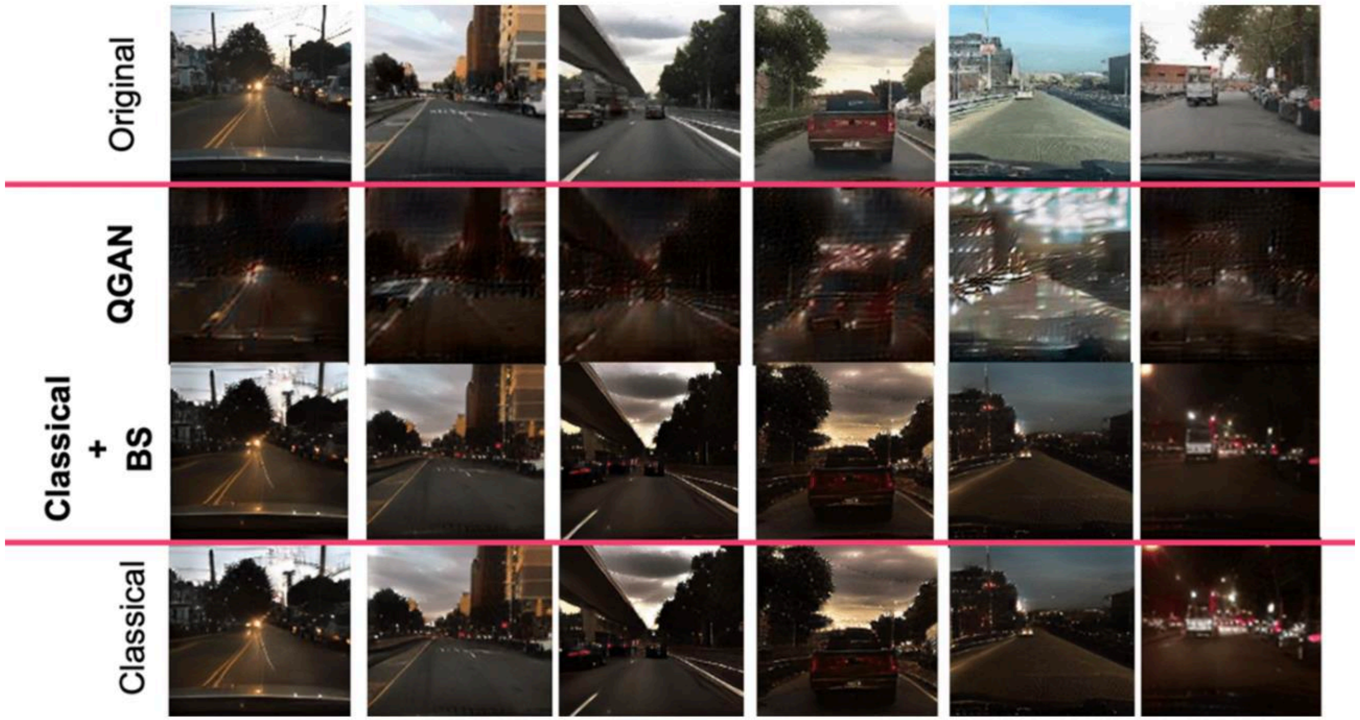
Generating night images by training the model on daytime images.

Photonic Enhanced Generative Model



Finding enzymes to clean up pollution

Challenges when finding new enzymes

- Finding the right docking configuration between the enzyme and the pollutant.
- Screening large databases of potential candidates.
- Predicting molecular properties.
- Modelling Molecular Flexibility and Dynamics

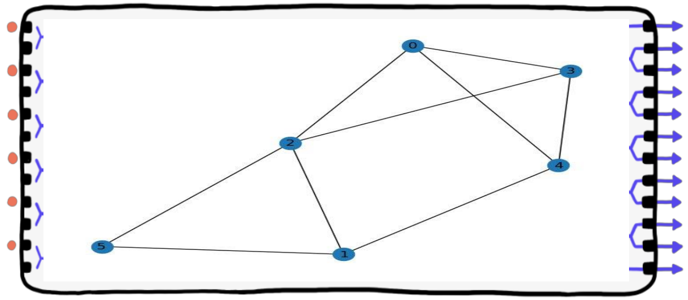
Mathematical Problems to solve

- Molecular docking (Maximum Clique Problem)
- Optimisation
- Machine learning
- Differential equations
- Monte Carlo methods

Open Quantum Institute – Use-case

OQI Open Quantum Institute

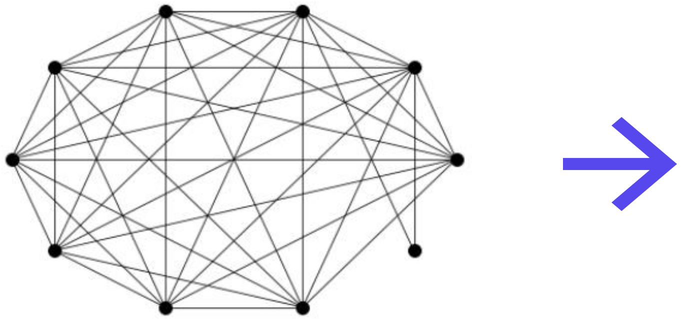
Finding enzymes to clean up pollution



Finding the right docking configuration between the enzyme and the pollutant.

Comparing **docking configuration** by finding dense subgraphs.

Photonic native graph algorithm



$$A = \begin{pmatrix} 0 & 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 & 0 \\ 1 & 0 & 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 \\ 1 & 1 & 0 & 1 & 1 & 1 & 1 & 1 & 1 & 1 \\ 1 & 1 & 1 & 0 & 1 & 1 & 1 & 1 & 1 & 0 \\ 1 & 1 & 1 & 1 & 0 & 1 & 1 & 1 & 1 & 0 \\ 1 & 1 & 1 & 1 & 1 & 0 & 1 & 1 & 1 & 0 \\ 1 & 1 & 1 & 1 & 1 & 1 & 0 & 1 & 1 & 0 \\ 1 & 1 & 1 & 1 & 1 & 1 & 1 & 0 & 1 & 0 \\ 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 & 0 & 0 \\ 0 & 1 & 1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \end{pmatrix}$$

Fig. A graph and its corresponding adjacency matrix