



How Quantum Machine Learning Works with Quantum Variational Circuits

Quantum machine learning (QML) combines classical machine learning with quantum computing. We'll explore the basics of quantum computing and how QML leverages quantum variational circuits for advanced machine learning applications.

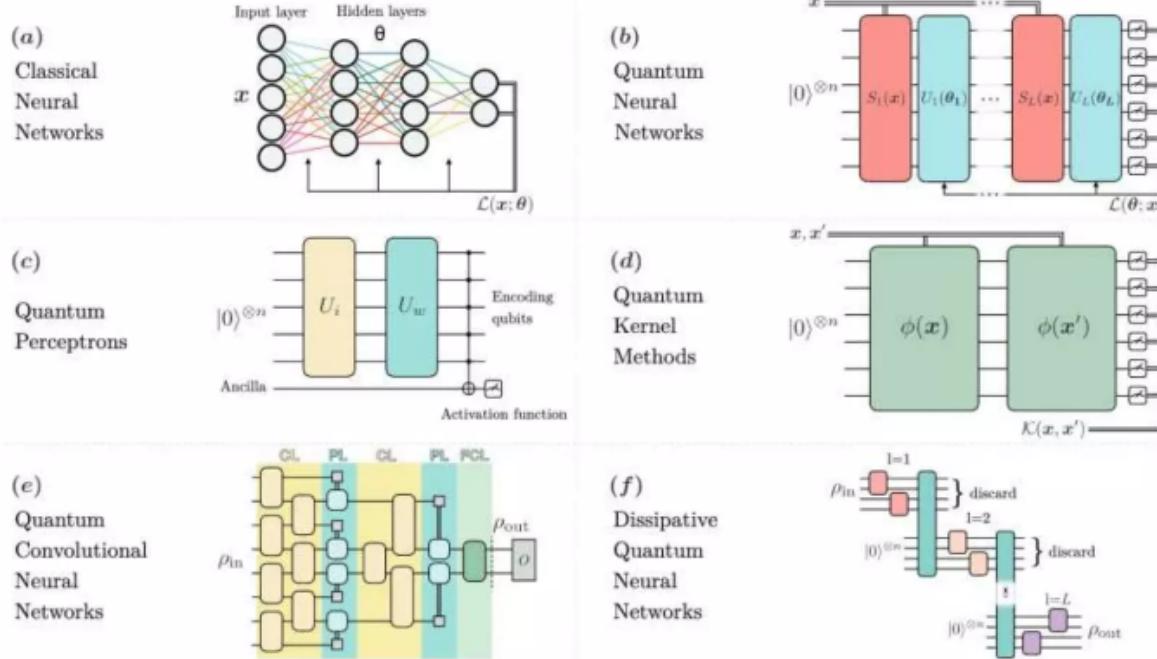
Introduction to Quantum Machine Learning

1 Definition

Quantum machine learning uses quantum computing to process and analyse data for advanced machine learning applications.

2 Advantages Over Classical Machine Learning

Quantum computing allows for the processing of vast amounts of data exponentially faster than classical computing, making QML ideal for big data analysis.



Source: S. Mangini et al 2021 EPL 134 1000

Quantum Computing Basics

1

Qubits and Gates

Qubits are the building blocks of quantum computing. They are governed by quantum gates, which change the state of the qubit.

2

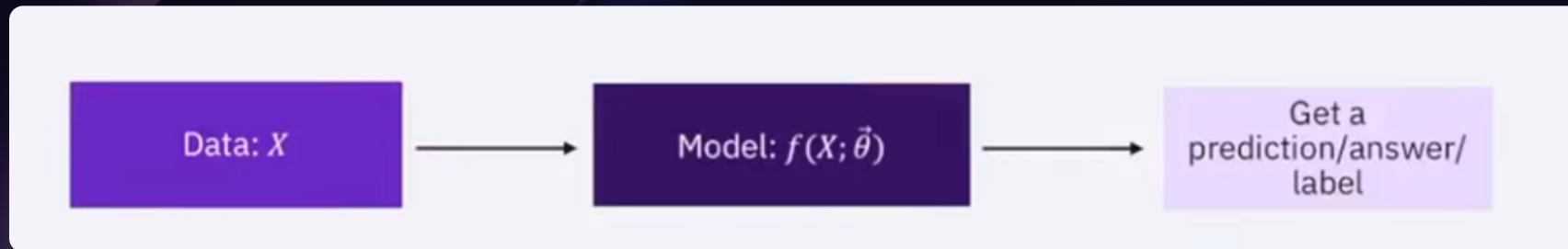
Quantum Circuits

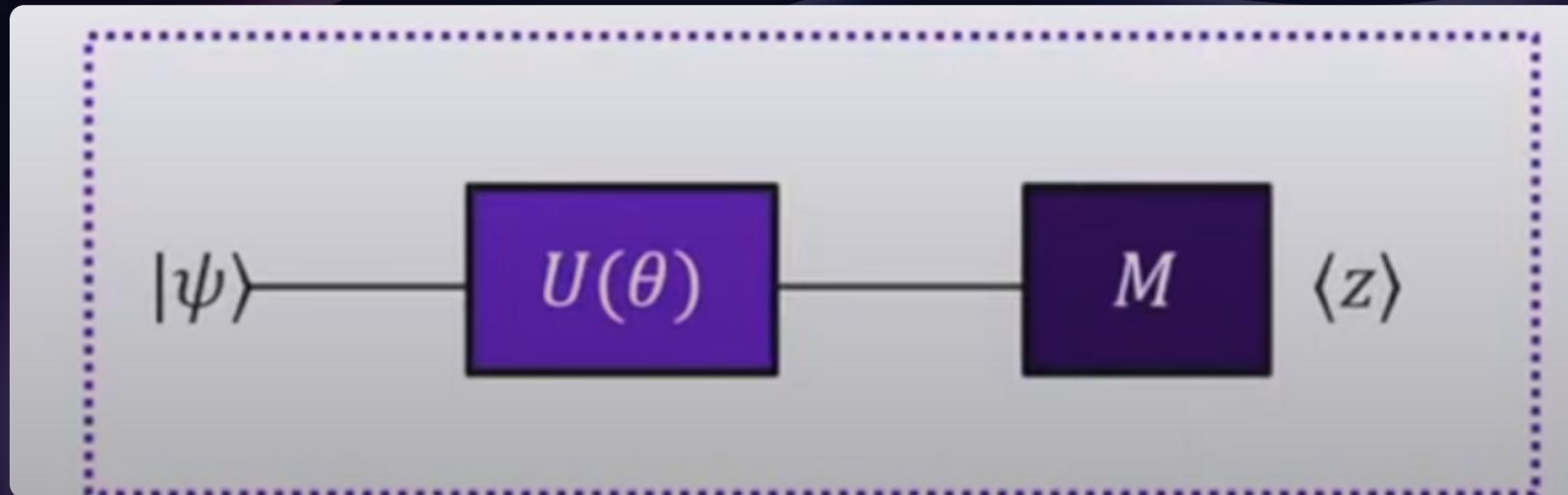
These are circuits built from quantum gates and used to process information in a quantum computer.

3

Quantum Parallelism

Unlike classical computing, quantum computing enables parallel processing, meaning a quantum computer can run multiple operations simultaneously.





Variational circuit as a classifier

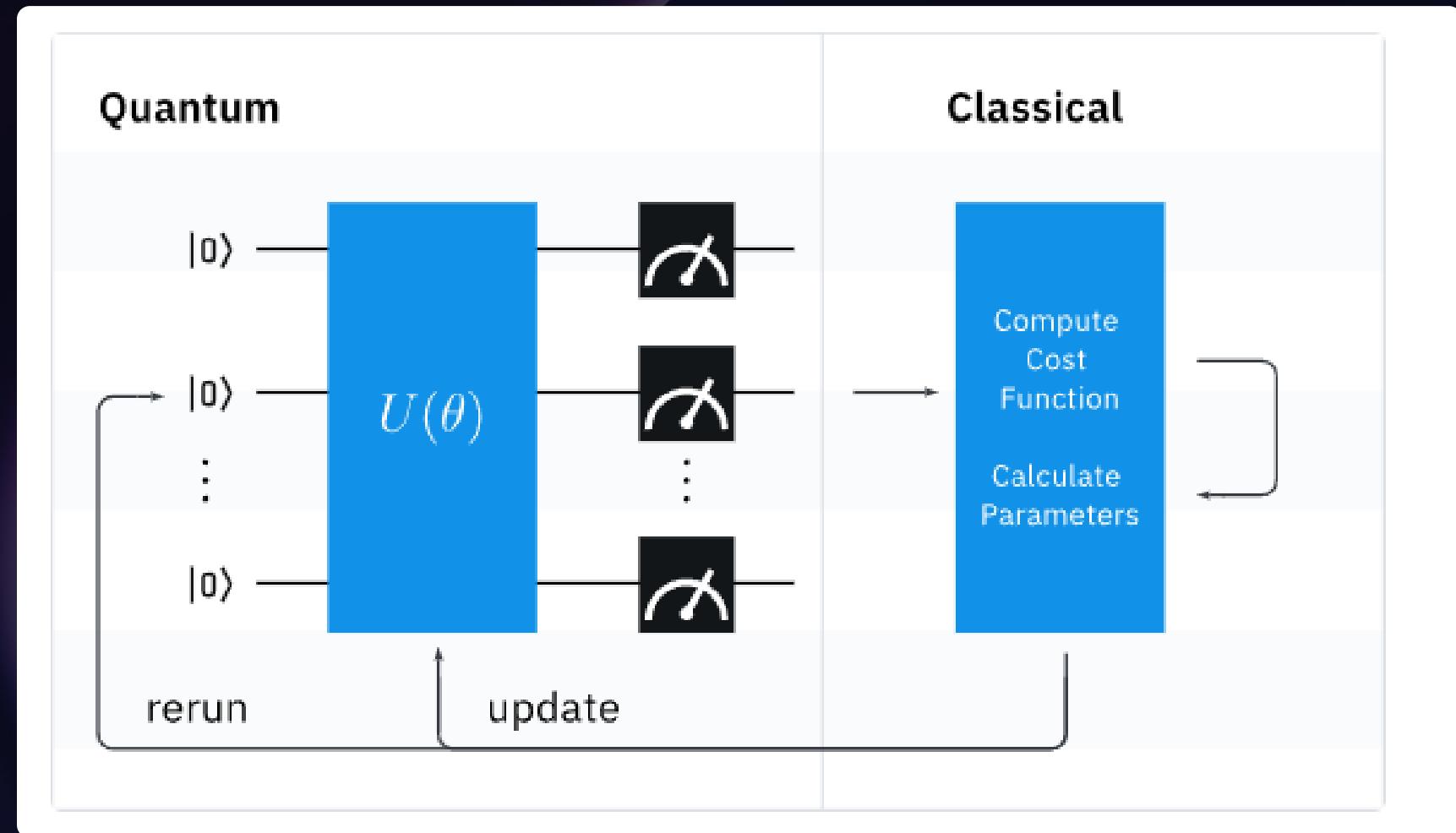
Task: Train a quantum circuit on labelled samples in order to predict labels for new data

Step 1: Encode the classical data into a quantum state

Step 2: Apply a parameterized model

Step 3: Measure the circuit to extract labels

Step 4: Use optimization techniques (like gradient descent) to update model parameters



Quantum Variational Circuits (QVC)

Explanation of Variational Circuits

Variational circuits are a type of quantum circuit used for quantum optimisation problems. They are built by applying a set of gates to the qubits, similar to a neural network.

How QVC is Employed in Quantum Machine Learning

QVC leverages variational circuits to create quantum machine learning models capable of processing large amounts of data for various applications.

Examples of QVC Implementations in Quantum Machine Learning

Applications of QVC in quantum machine learning include quantum clustering and feature selection.

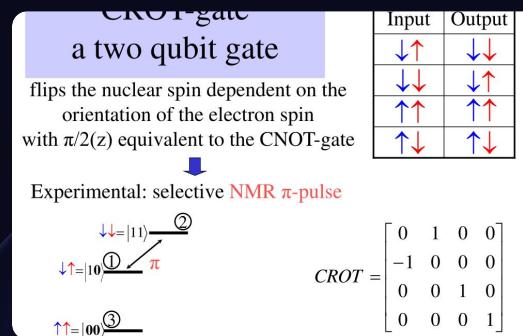


Illustrations



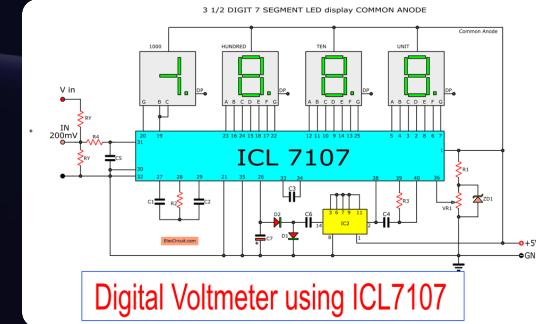
Quantum Circuits

This diagram shows the components of a quantum circuit and how it processes information.



Qubit Gates

These quantum gates control the transformation of qubits, the building blocks of quantum computing.



Comparison Between Quantum and Classical Circuits

Quantum circuits have the ability to process large amounts of data exponentially faster than their classical counterparts.

Challenges and Limitations

1

Error Correction and Noise Reduction

Quantum computers are sensitive to disturbance from their environment, so error correction and noise reduction remain significant challenges.

2

Scalability and Hardware Limitations

Quantum computers require specialised hardware with specific, complex requirements, making scalability a significant challenge.

3

Potential Solutions and Future Developments

New hardware architectures and software are being developed by researchers to mitigate the challenges facing quantum computing and quantum machine learning.



Conclusion

Recap of Major Points

Quantum machine learning leverages quantum variational circuits to process large amounts of data for various applications. Challenges remain, including error correction and scalability, but progress is being made in developing new hardware and software solutions.

Current Work

Research into quantum machine learning is ongoing, with application across finance, healthcare and other industries.

Implications for Future of Machine Learning and Quantum Technology

Quantum machine learning represents a significant leap forward in the application and development of quantum technology. It has broad-reaching implications for multiple industries and fields, and its full potential is yet to be realised.