An Introduction to Quantum Natural Language Processing (QNLP)

Part 2 :

Basics of Quantum Machine Learning

Outline of the lecture

Outline of the lecture

- Brief Introduction to Machine Learning

Outline of the lecture

- Brief Introduction to Machine Learning
- Neural Network Basics

Outline of the lecture

- Brief Introduction to Machine Learning
- Neural Network Basics
- Quantum Machine Learning (QML) – Variational Circuits & QML Architecture

Outline of the lecture

- Brief Introduction to Machine Learning
- Neural Network Basics
- Quantum Machine Learning (QML) – Variational Circuits & QML Architecture
- Quantum Neural Networks Briefly

Brief Introduction to Machine Learning

Brief Introduction to Machine Learning

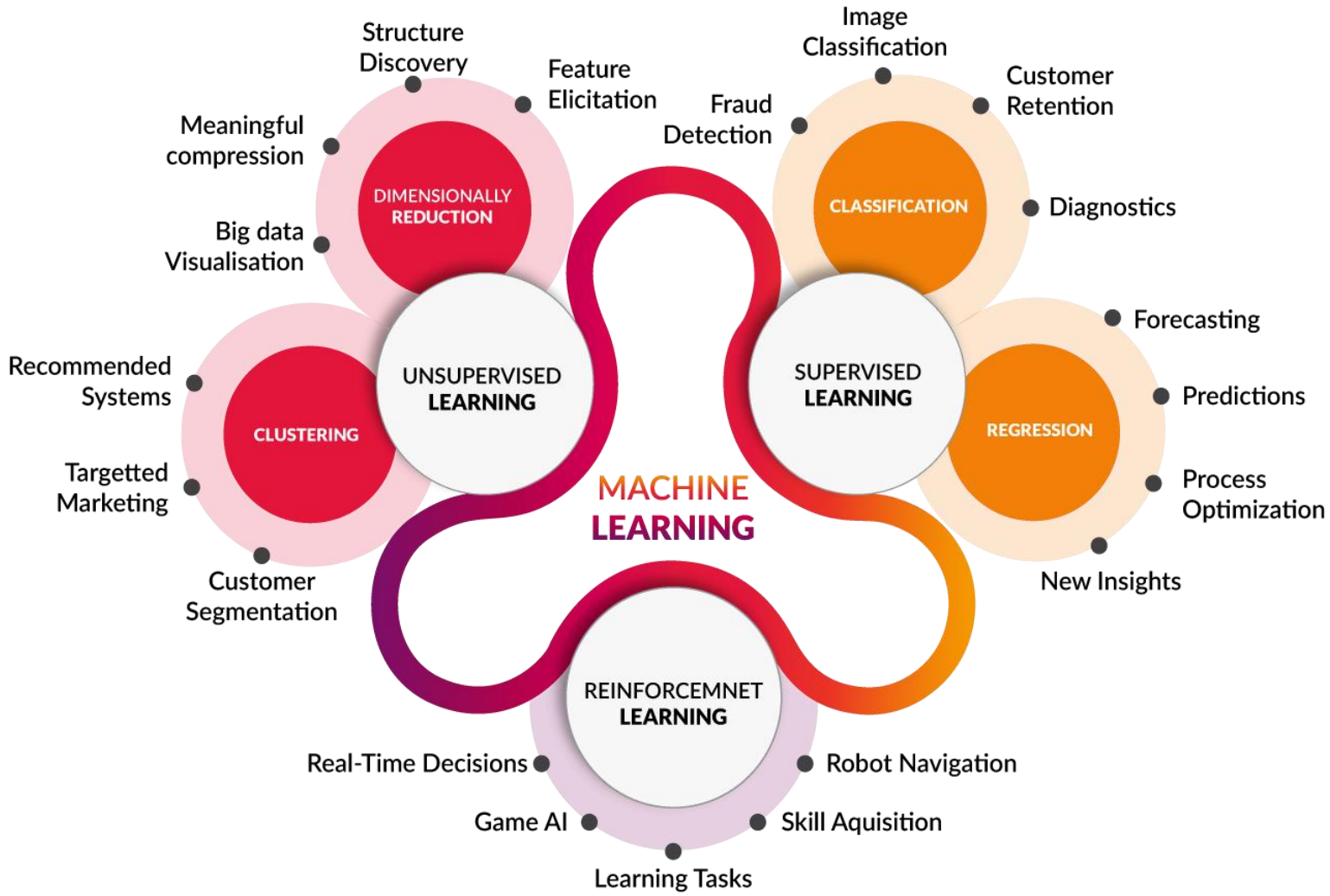


Image Source : [COGNITIVE COMPUTING AND MACHINE LEARNING - Cognub]

Brief Introduction to Machine Learning

Machine Learning Algorithms

Brief Introduction to Machine Learning

Machine Learning Algorithms

Data Type/Algorithm Type	Unsupervised	Supervised
Continuous	Clustering & Dimensionality Reduction ★ K-Means ★ PCA	Regression ★ Linear ★ Polynomial Decision Trees Random Forests Neural Networks
Categorical	Association Analysis ★ Apriori ★ FP-Growth Hidden Markov Model	Classification ★ KNN ★ Decision Trees ★ Logistic Regression ★ Naive Bayes ★ SVM ★ Neural Networks

Brief Introduction to Machine Learning

Introduction to Machine Learning Concludes

Neural Network Basics

Neural Network Basics

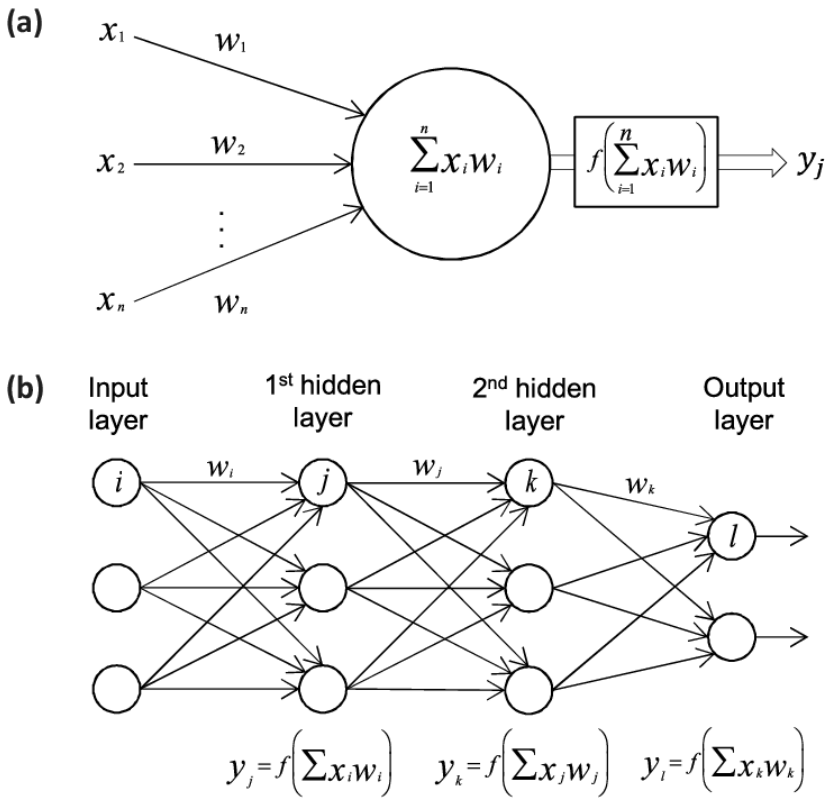
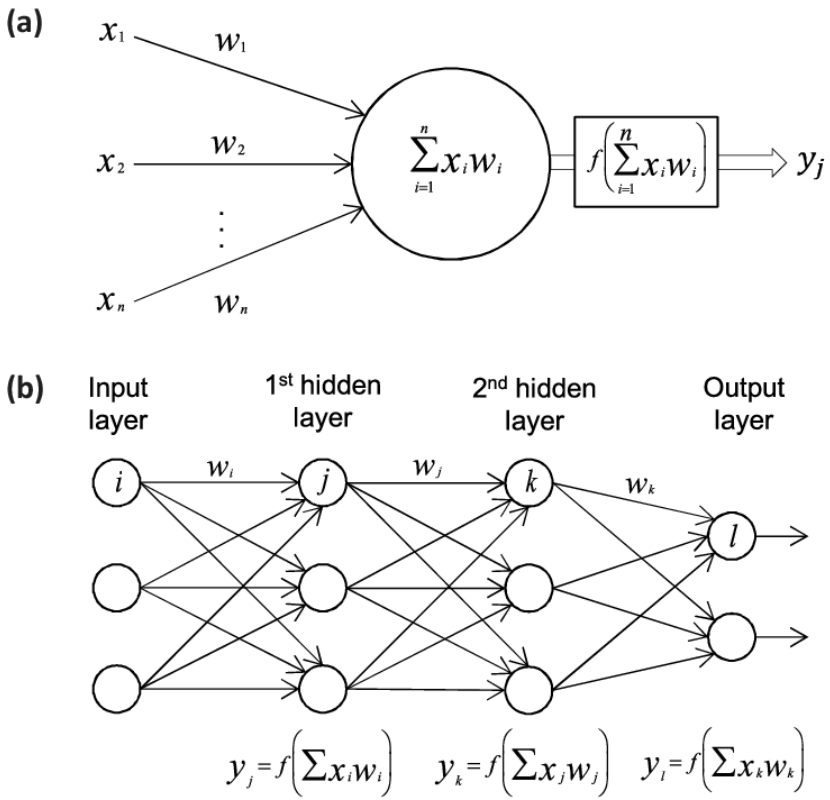


Image Source : https://www.researchgate.net/figure/a-The-building-block-of-deep-neural-networks-artificial-neuron-or-node-Each-input-x_fig1_312205163

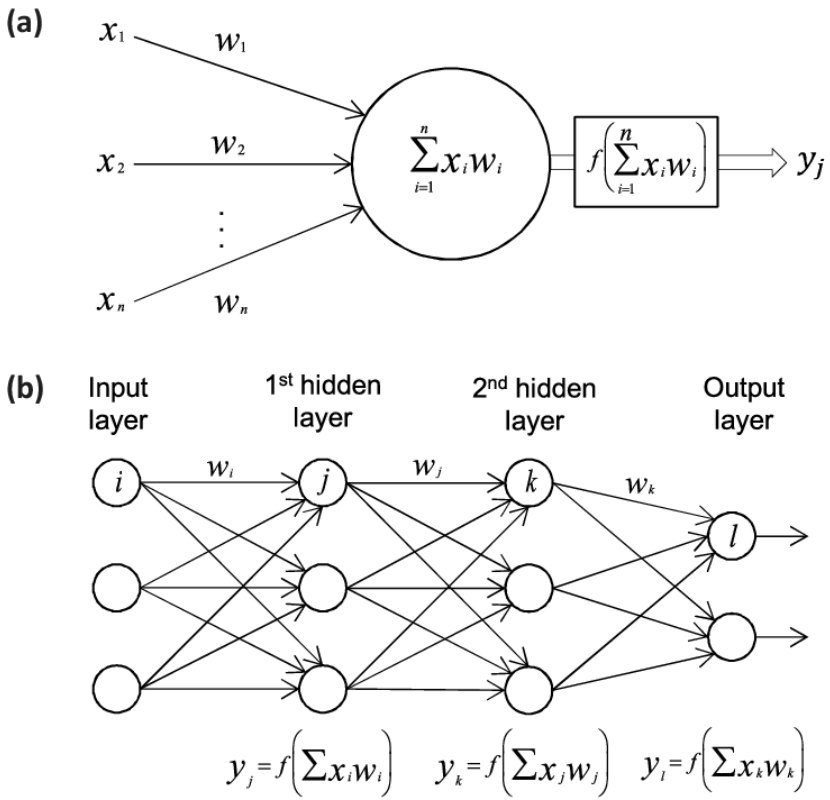
Neural Network Basics



- Neural networks have modifiable or trainable (variational) weights

Image Source : https://www.researchgate.net/figure/a-The-building-block-of-deep-neural-networks-artificial-neuron-or-node-Each-input-x_fig1_312205163

Neural Network Basics



- Neural networks have modifiable or trainable (variational) weights
- These weights are optimized by an optimizer and learned by the model

Image Source : https://www.researchgate.net/figure/a-The-building-block-of-deep-neural-networks-artificial-neuron-or-node-Each-input-x_fig1_312205163

Neural Network Basics

Neural Network Basics Concludes

Quantum Machine Learning (QML)

Quantum Machine Learning (QML)

Type of Data/Type of Algorithm	Classical Algorithm	Quantum Algorithm
Classical Data	CC	CQ
Quantum Data	QC	QQ

Quantum Machine Learning (QML)

Type of Data/Type of Algorithm	Classical Algorithm	Quantum Algorithm
Classical Data	CC	CQ
Quantum Data	QC	QQ

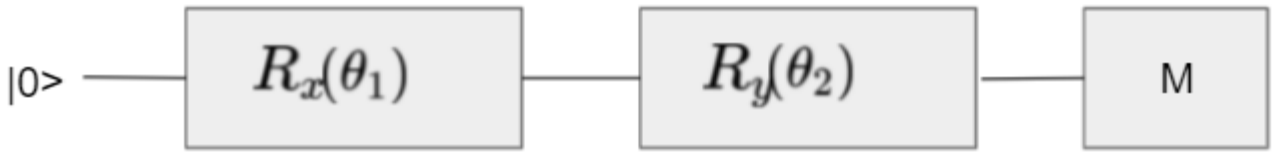
Quantum Machine Learning – Variational Circuits

Quantum Machine Learning – Variational Circuits

Variational Circuits - Circuits depend on tuneable (variational) parameters

Quantum Machine Learning – Variational Circuits

Variational Circuits - Circuits depend on tuneable (variational) parameters



Quantum Machine Learning – Variational Circuits

Variational Circuits - Circuits depend on tuneable (variational) parameters

In this circuit θ_1 and θ_2 are the variational parameters. Rx and Ry are rotations around X and Y axis respectively. θ_1 and θ_2 are analogous to trainable weights of a neural network

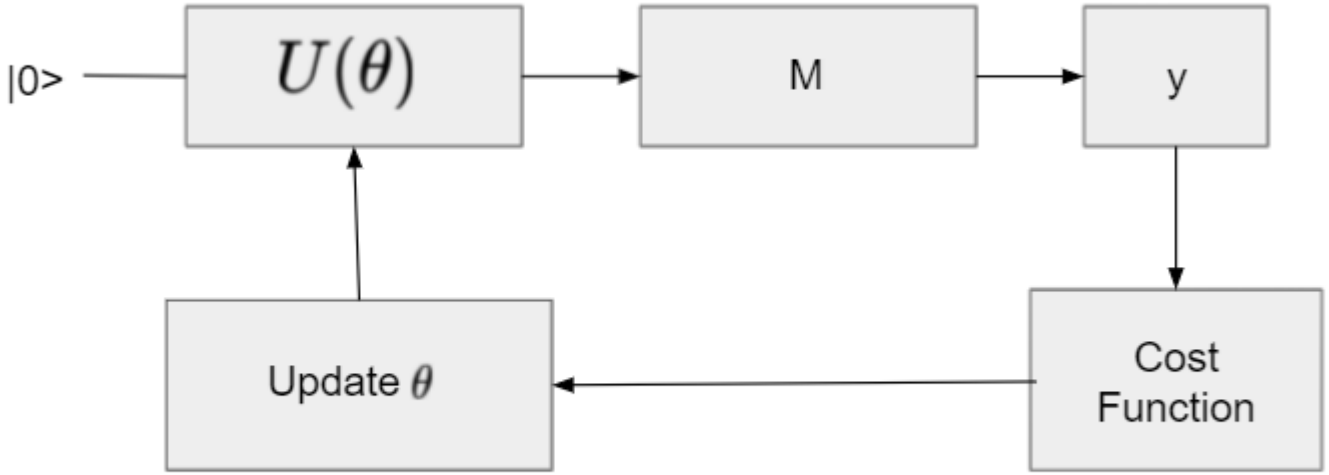
Basic Quantum Machine Learning (QML) Architecture

Basic Quantum Machine Learning (QML) Architecture

The basic QML architecture is very similar to that of the classical machine learning models.

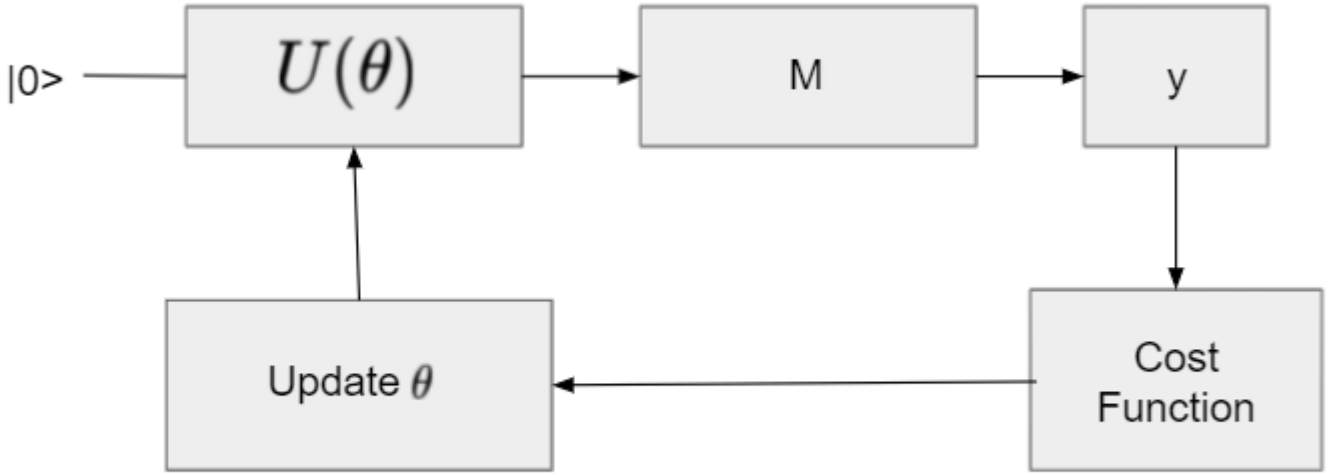
Basic Quantum Machine Learning (QML) Architecture

The basic QML architecture is very similar to that of the classical machine learning models.



Basic Quantum Machine Learning (QML) Architecture

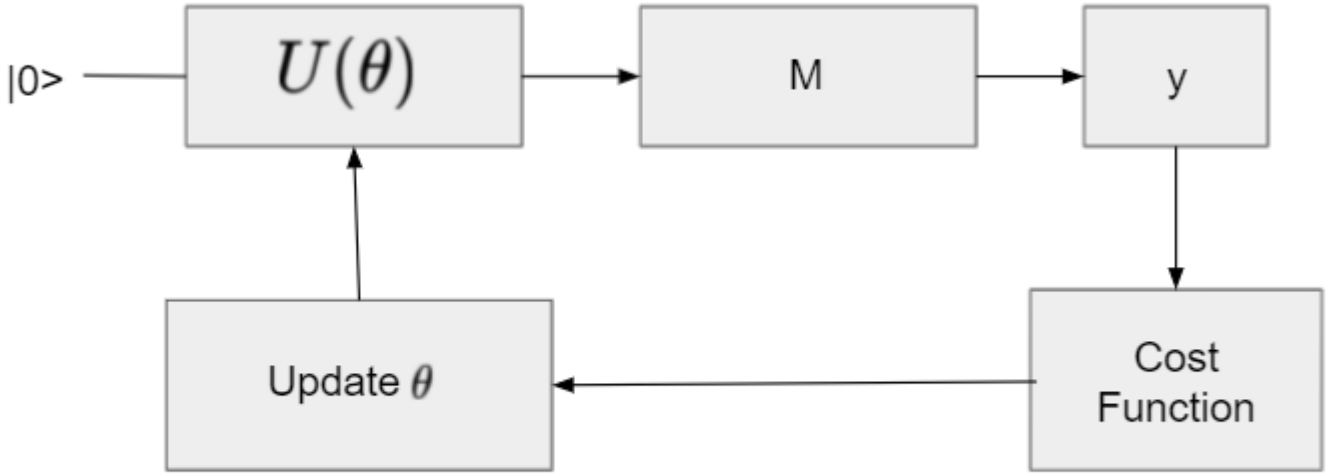
The basic QML architecture is very similar to that of the classical machine learning models.



- Non linearity in a quantum setting can come from the measurements

Basic Quantum Machine Learning (QML) Architecture

The basic QML architecture is very similar to that of the classical machine learning models.



- Non linearity in a quantum setting can come from the measurements
- The parameters θ are learned by the model and optimized by a classical optimizer

Quantum Machine Learning (QML)

Quantum Machine Learning (QML) Concludes

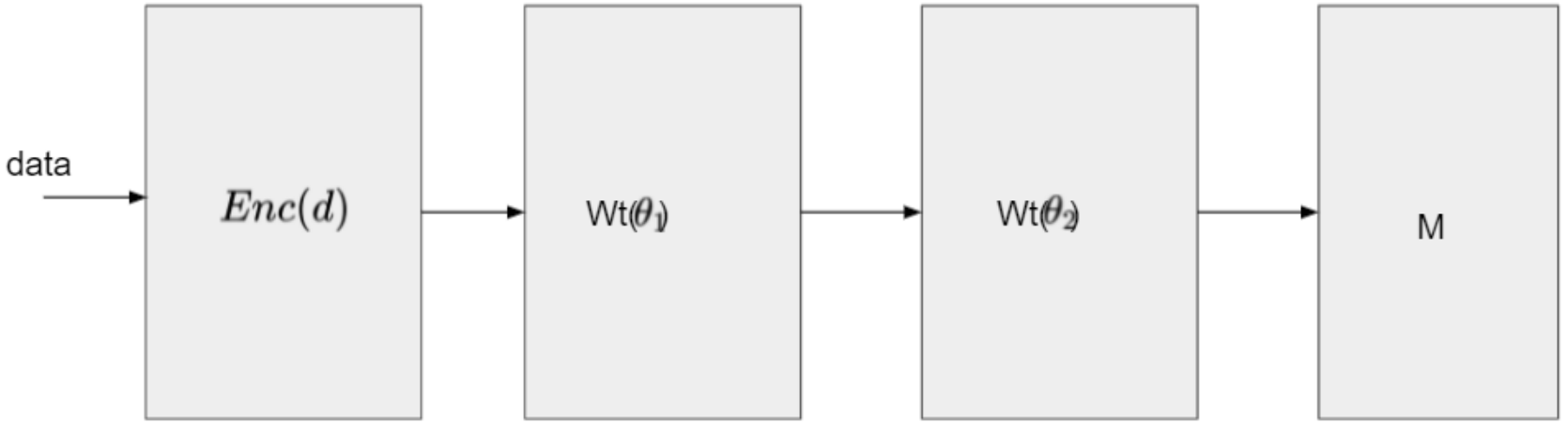
Quantum Neural Networks (QNNs)

Quantum Neural Networks (QNNs)

Quantum Neural Network architecture is similar to that of the classical neural networks.

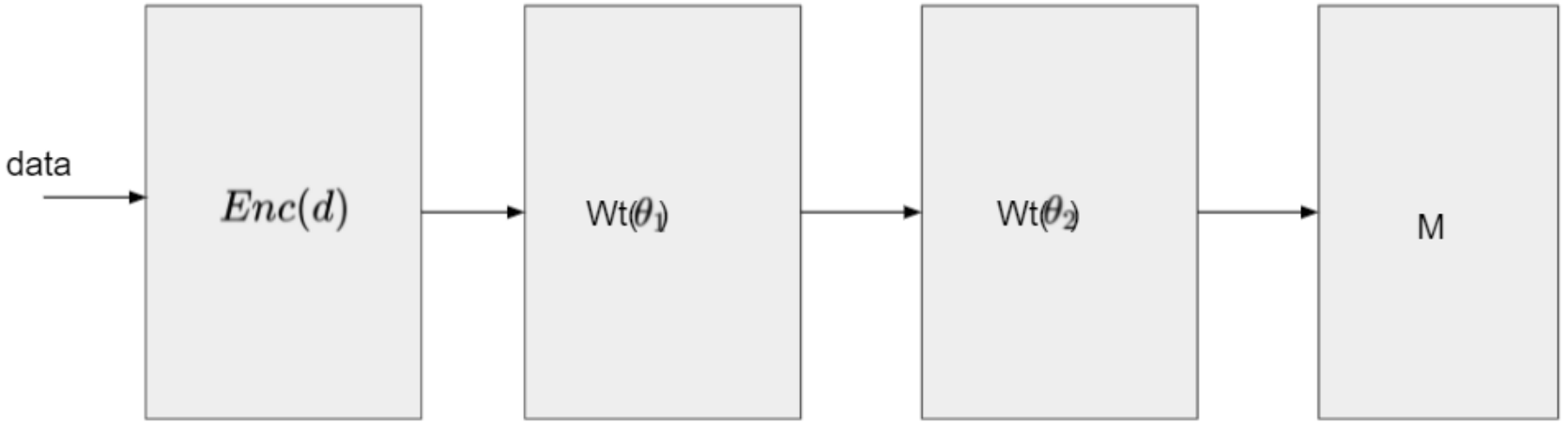
Quantum Neural Networks (QNNs)

Quantum Neural Network architecture is similar to that of the classical neural networks.



Quantum Neural Networks (QNNs)

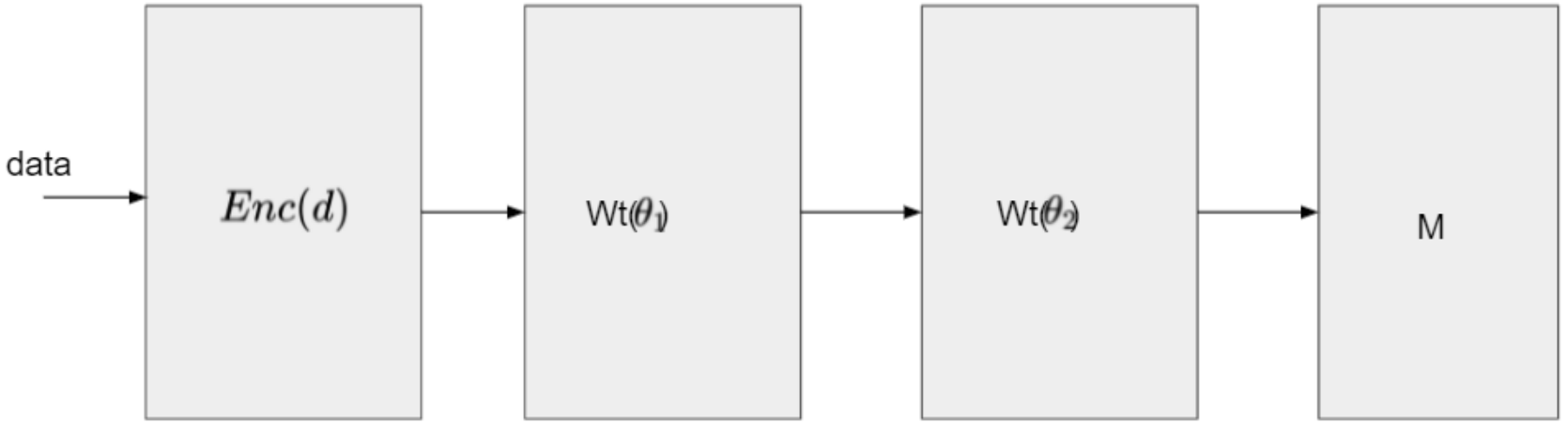
Quantum Neural Network architecture is similar to that of the classical neural networks.



- The encoder converts classical data into quantum states by using schemes such as amplitude encoding, phase encoding or basis encoding

Quantum Neural Networks (QNNs)

Quantum Neural Network architecture is similar to that of the classical neural networks.



- The encoder converts classical data into quantum states by using schemes such as amplitude encoding, phase encoding or basis encoding

- Wt(θ_1) & Wt(θ_2) are variational circuits analogous to weights present in hidden layers of classical neural networks.

Quantum Neural Networks (QNNs)

Quantum Neural Networks (QNNs) Concludes

References

- PennyLane for Quantum Machine Learning, https://pennylane.ai/qml/index.html
- John van de Wetering, “ZX-calculus for the working quantum computer scientist”, https://arxiv.org/abs/2012.13966
- Bob Coecke, “Foundations for Near Term Quantum Natural Language Processing”, https://arxiv.org/abs/2012.03755
- Bob Coecke, “Compositionality as we see it, everywhere around us”, https://arxiv.org/abs/2110.05327
- Stephen Clark, “Something Old, Something New: Grammar-based CCG Parsing with Transformer Models”, https://arxiv.org/abs/2109.10044
- Bob Coecke, Aleks Kissinger, “Picturing Quantum Processes”, Cambridge University Press, 2017
- Joachim Lambek, “From Word to Sentence: A Computational Algebraic Approach to Grammar”, Polimetrica s.a.s., 2008

Thank you so much!