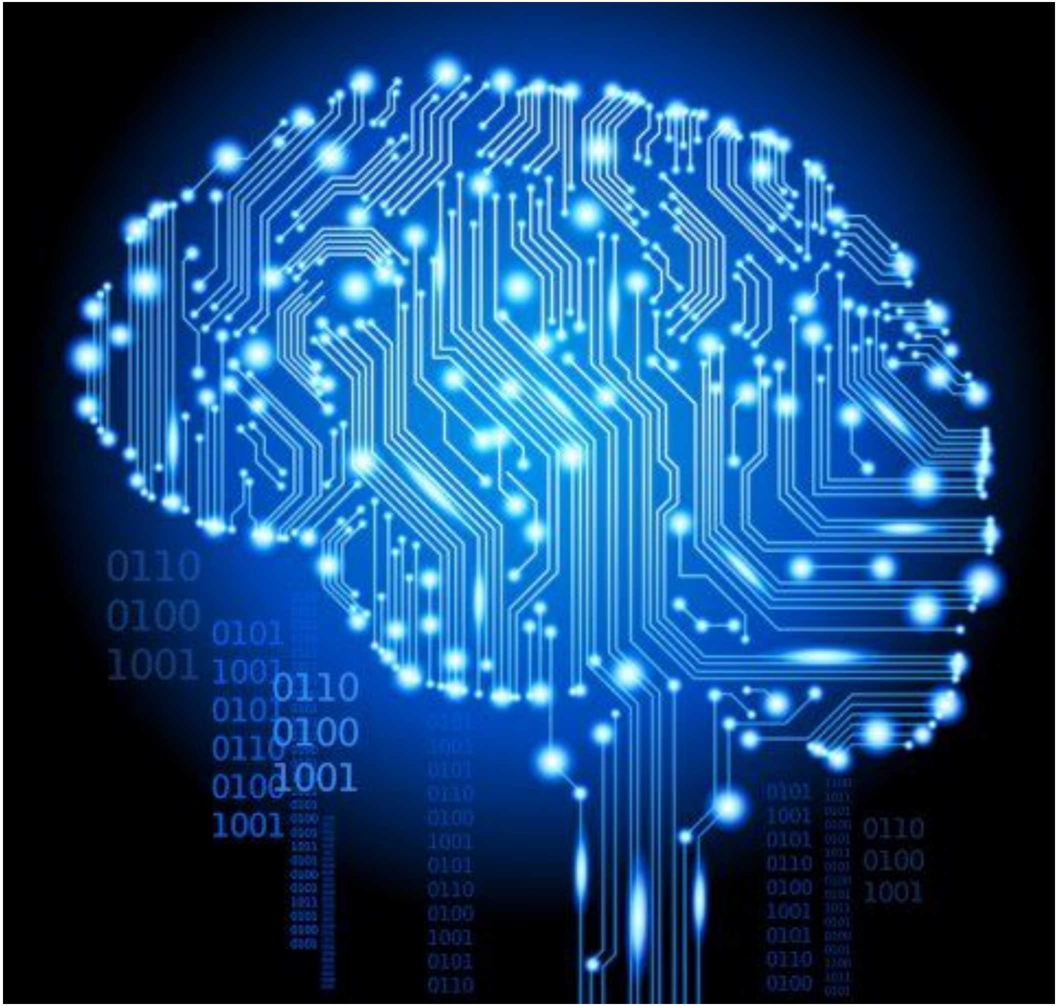
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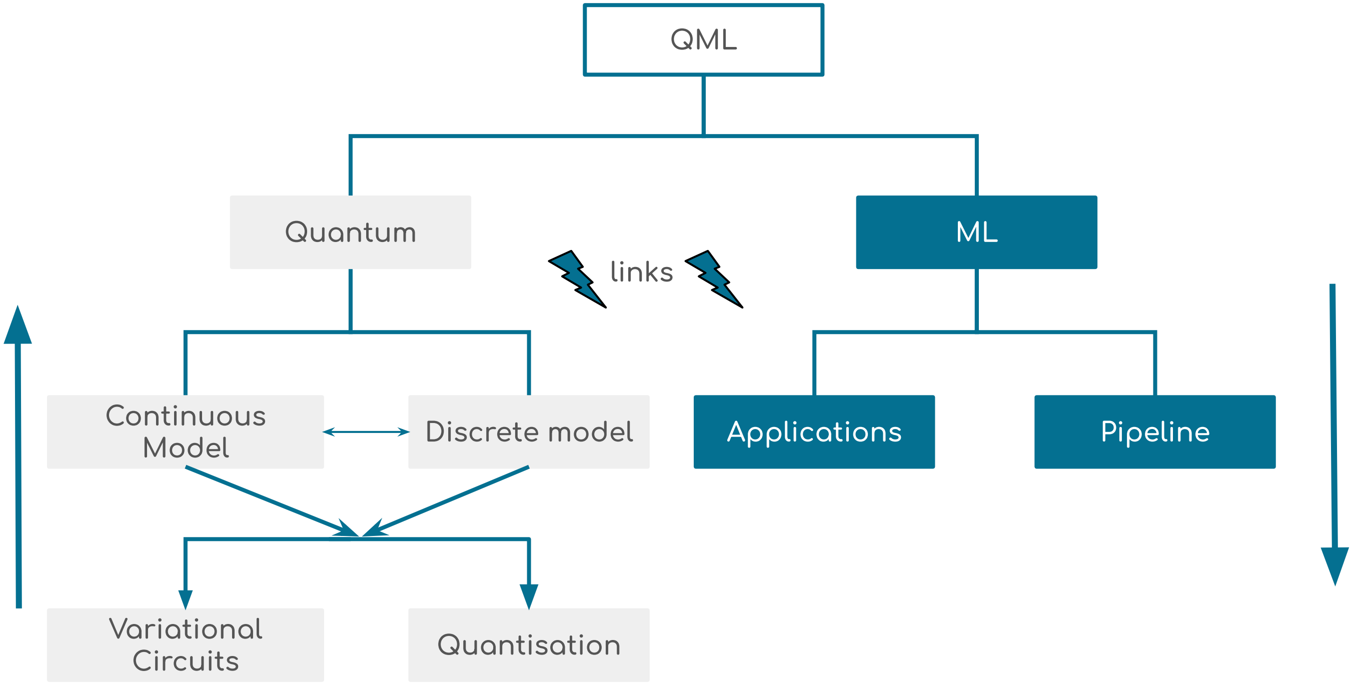
Speaker

Kareem El-Safty

- AI & ML Engineer “Computer Vision”
- Dean of School of AI.
- Researcher in QML.

Agenda


QML
Quantum
ML
links
Continuous Model
Discrete model
Applications
Pipeline
Variational Circuits
Quantisation

ML

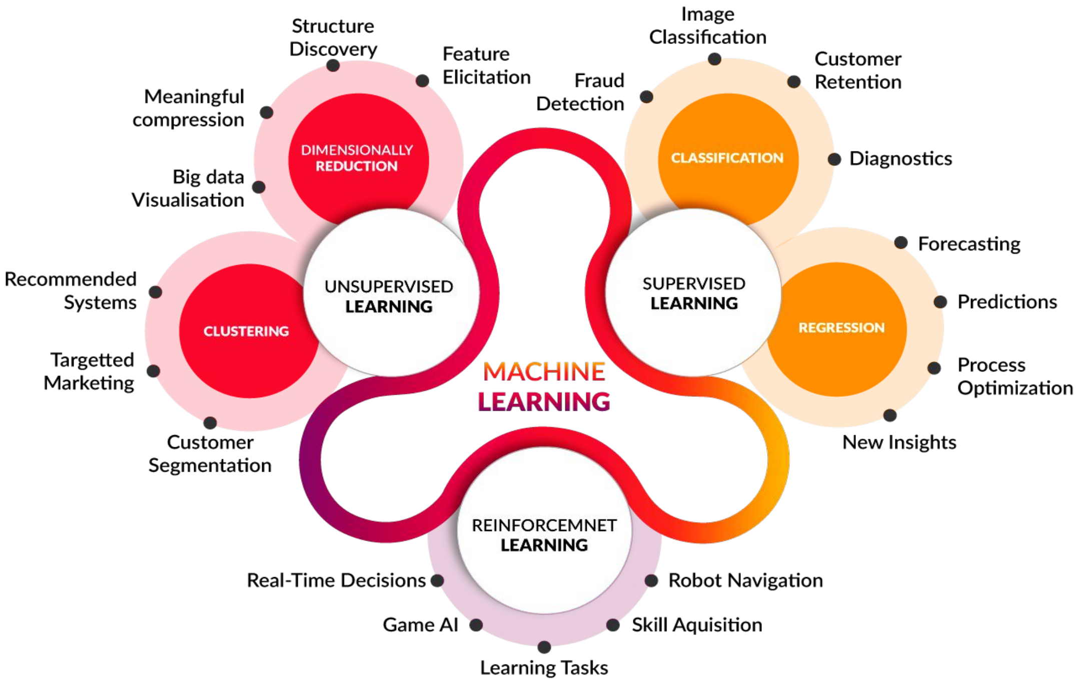
Not Inference But Prediction [1,2]

Not AI

It's Smart Decisions

Machine Learning is simply giving a machine the cognitive ability to perform a task without human interference in terms of accuracy

ML Applications



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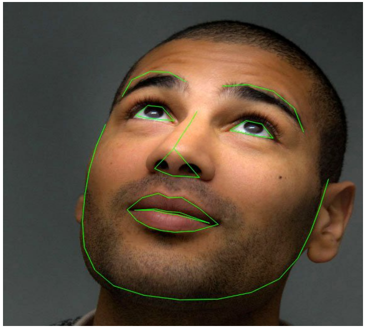
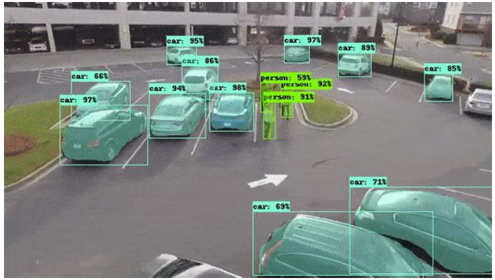
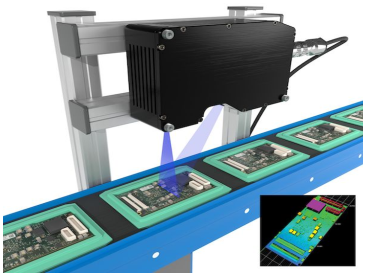
Practical Examples



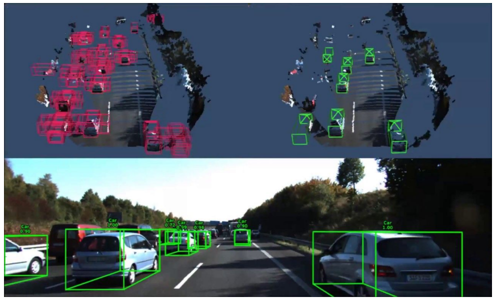
[1], [2]



[3], [4], [5]

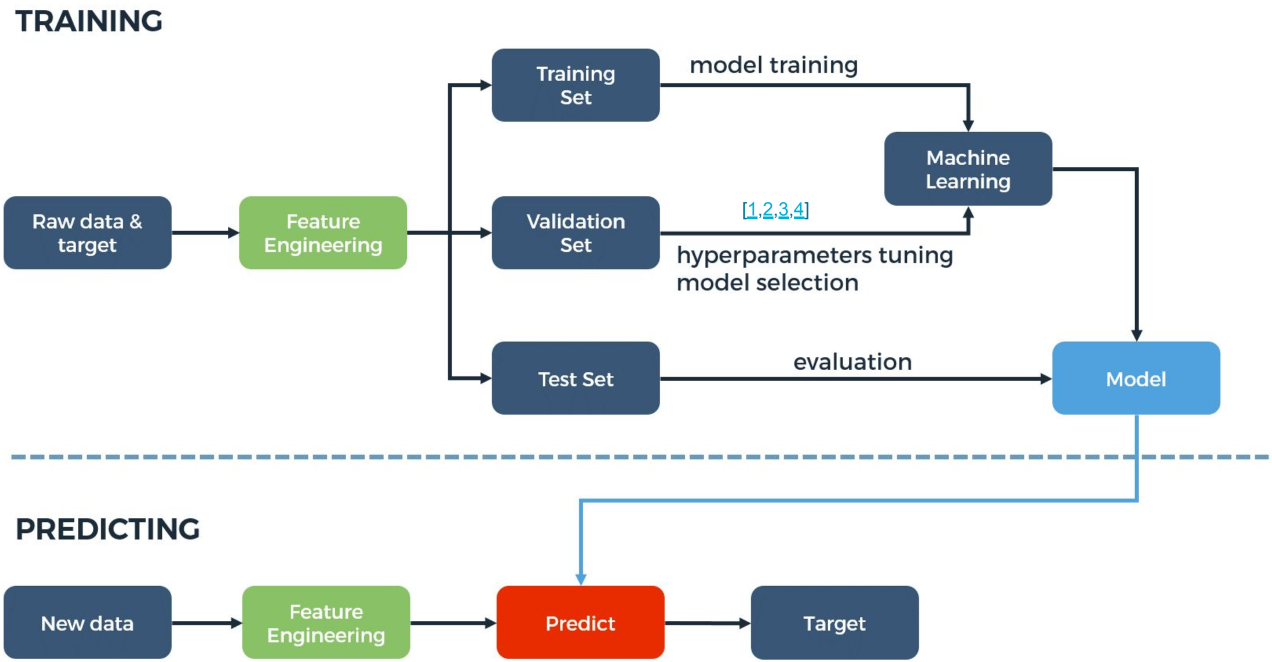


[6]



[7]

ML Pipeline

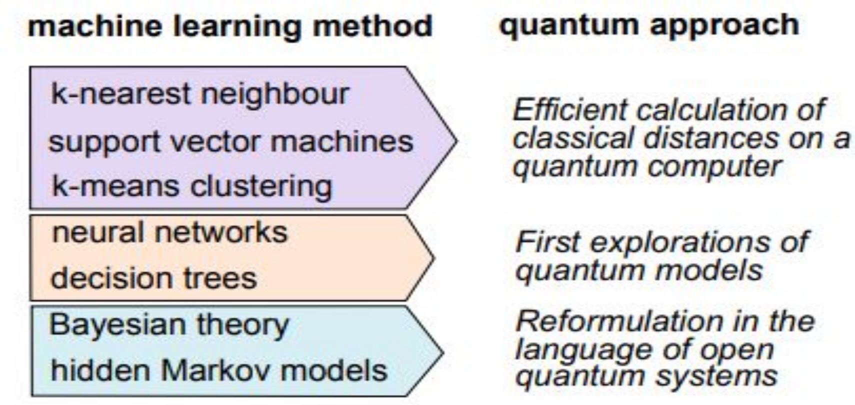


TRAINING
Training Set
model training
Machine Learning
Raw data & target
Feature Engineering
Validation Set
[1,2,3,4]
hyperparameters tuning
model selection
Test Set
evaluation
Model
PREDICTING
New data
Feature Engineering
Predict
Target

links

1	RBM [1]	• Energy Function
2	Neural Networks demystified	• Physics explains the inner workings of NNs [2,3]
3	Reinforcement learning	• Error correcting circuits [4,5,6]

Quantisation



[1,2,3,4,5]

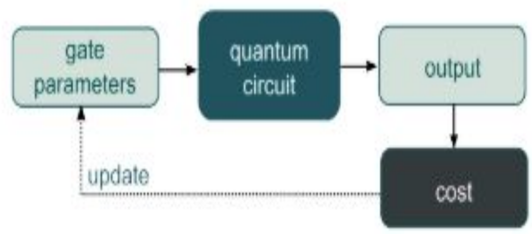
Quantisation cont.

Method	Speedup	Amplitude amplification	HHL	Adiabatic	qRAM
Bayesian inference[106,107]	$O(\sqrt{N})$	Yes	Yes	No	No
Online perceptron[108]	$O(\sqrt{N})$	Yes	No	No	Optional
Least-squares fitting[9]	$O(\log N)$*	Yes	Yes	No	Yes
Classical Boltzmann machine[20]	$O(\sqrt{N})$	Yes/No	Optional/No	No/Yes	Optional
Quantum Boltzmann machine[22,61]	$O(\log N)$*	Optional/No	No	No/Yes	No
Quantum PCA[11]	$O(\log N)$*	No	Yes	No	Optional
Quantum support vector machine[13]	$O(\log N)$*	No	Yes	No	Yes
Quantum reinforcement learning[30]	$O(\sqrt{N})$	Yes	No	No	No

*There exist important caveats that can limit the applicability of the method[51].

[1]

Variational circuits



- Meaning of variational concept [1,2,3,4]
- Different arch [5]
- Examples [6,7,8]
- Quantum Supremacy and NISQ [9]

Continuous Variable

	CV	Qubit
Basic element	Qumodes	Qubits
Information unit	1 nat ($\log_2 e$ bits)	1 bit
Relevant operators	Quadrature operators $\hat{x}, \hat{p}$ Mode operators $\hat{a}, \hat{a}^\dagger$	Pauli operators $\hat{\sigma}_x, \hat{\sigma}_y, \hat{\sigma}_z$
Common states	Coherent states $\lvert\alpha\rangle$ Squeezed states $\lvert z\rangle$ Number states $\lvert n\rangle$	Pauli eigenstates $\lvert 0/1\rangle, \lvert\pm\rangle, \lvert\pm i\rangle$
Common gates	Rotation, Displacement, Squeezing, Beamsplitter, Cubic Phase	Phase Shift, Hadamard, CNOT, T Gate
Common measurements	Homodyne $\hat{x}_\phi$, Heterodyne $Q(\alpha)$, Photon-counting $\lvert n\rangle\langle n\rvert$	Pauli-basis measurements $\lvert 0/1\rangle\langle 0/1\rvert, \lvert\pm\rangle\langle\pm\rvert, \lvert\pm i\rangle\langle\pm i\rvert$

image source

CV cont

How to Start:

- Quantum Optics and Information Science [1,2,3]
- Maths [4]
- papers [5,6]

Wonderful Examples

- [Continuous-variable quantum neural networks]
- [Quantum machine learning in feature Hilbert spaces]

Getting Started

1. Math
   1.1. math for ML, important book for Linear Algebra
   1.2. important book for explaining quantum computing
2. Machine Learning
   2.1. a 4 course specialization
   2.2. Deep learning [1,2]
3. Quantum Mechanics: "whoever tells you that you don't need a good understanding of QM to study quantum computing, do not trust him/her"
   3.1. QM 1, QM 2
   3.2. basic hardware [3,4]
      3.2.1. Quantum comm
         3.2.1.1. quantum internet [5]
         3.2.1.2. quantum crypto [6]
   3.3. Quantum computing
      3.3.1. [7], [8] and its series, QML [9]

Thank you