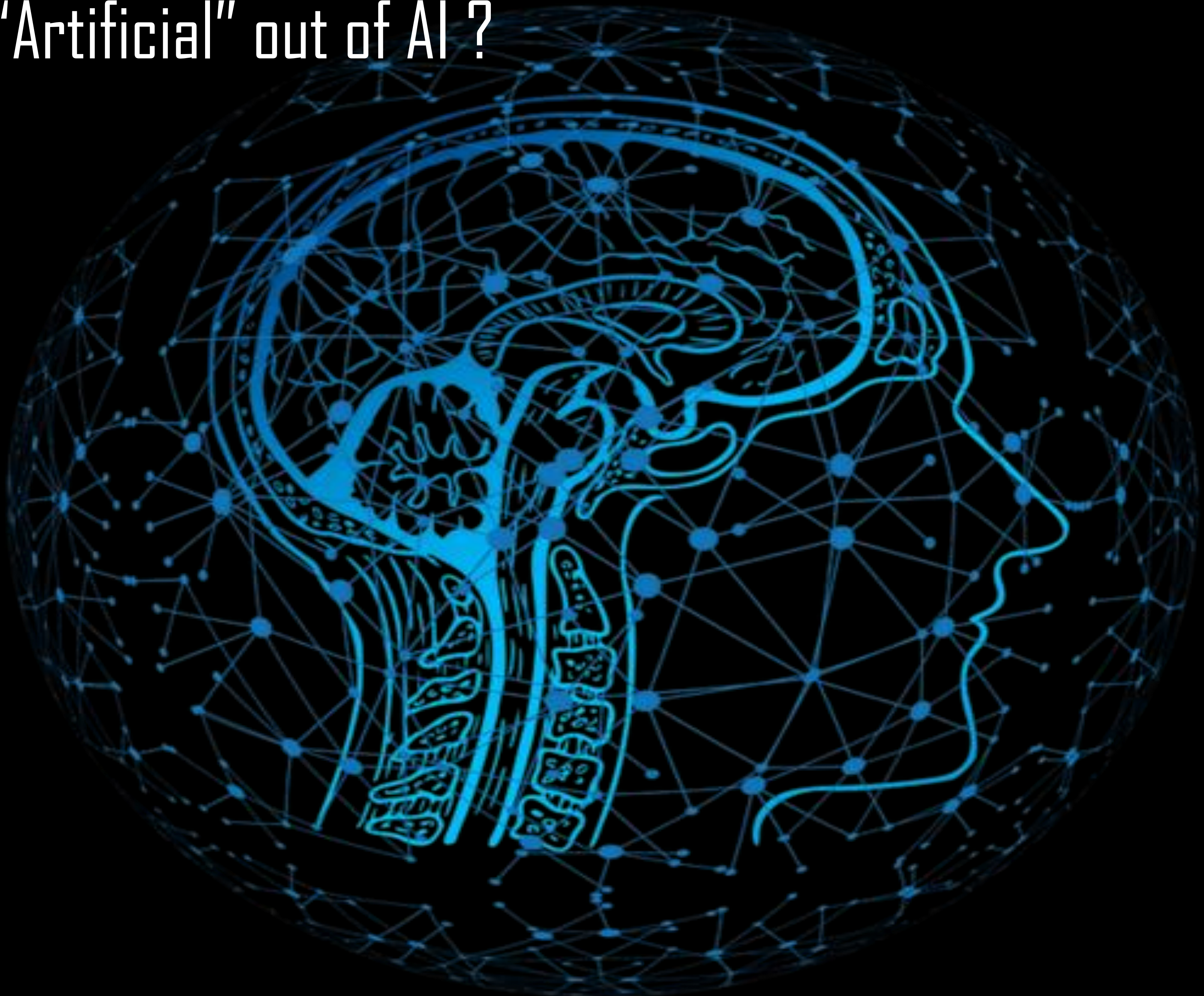
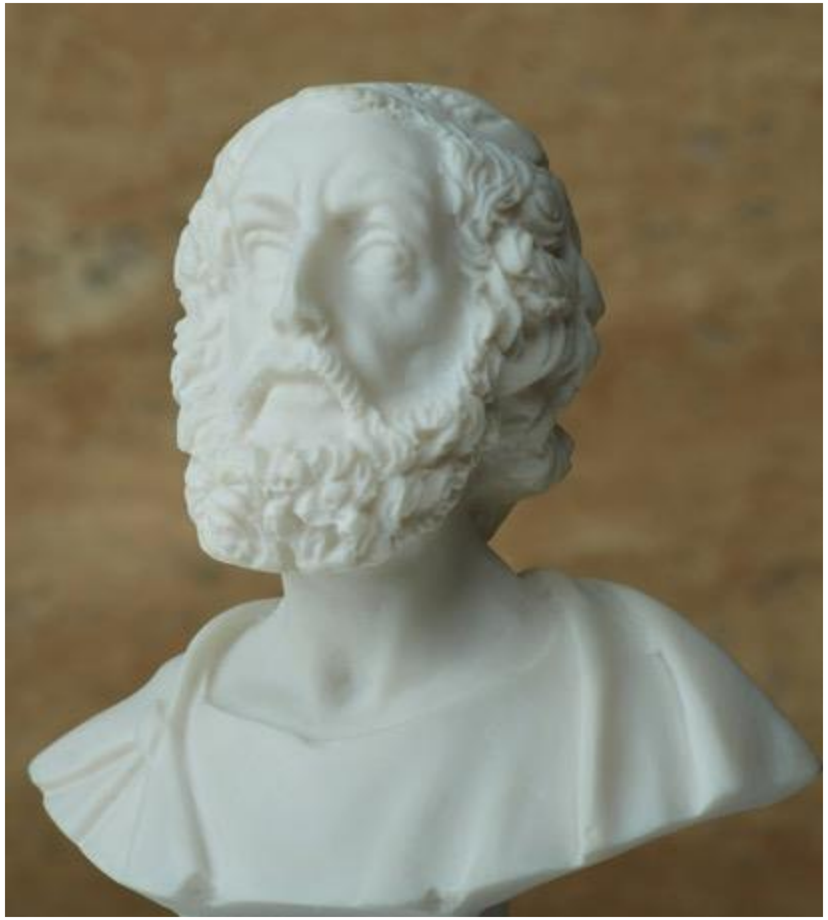
Taking the “Artificial” out of AI ?



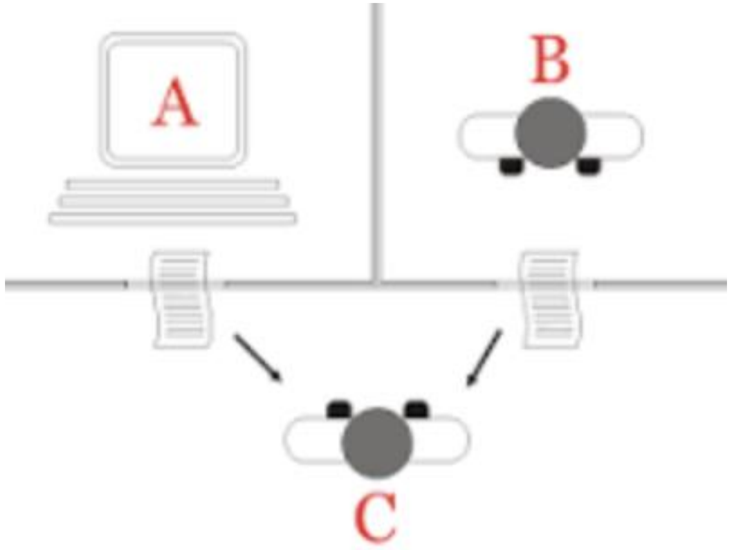
Will Quantum Computing take the artificial out of artificial intelligence?

- Is machine intelligence comparable to human intelligence?
- Is the brain a machine?
- Are we at our intellectual limit?
- What makes the brain special?
- Does Quantum Computing really make a difference to a Turing Test ?

“Artificial intelligence is the science of making machines do things that would require intelligence if done by men”
(Minsky)



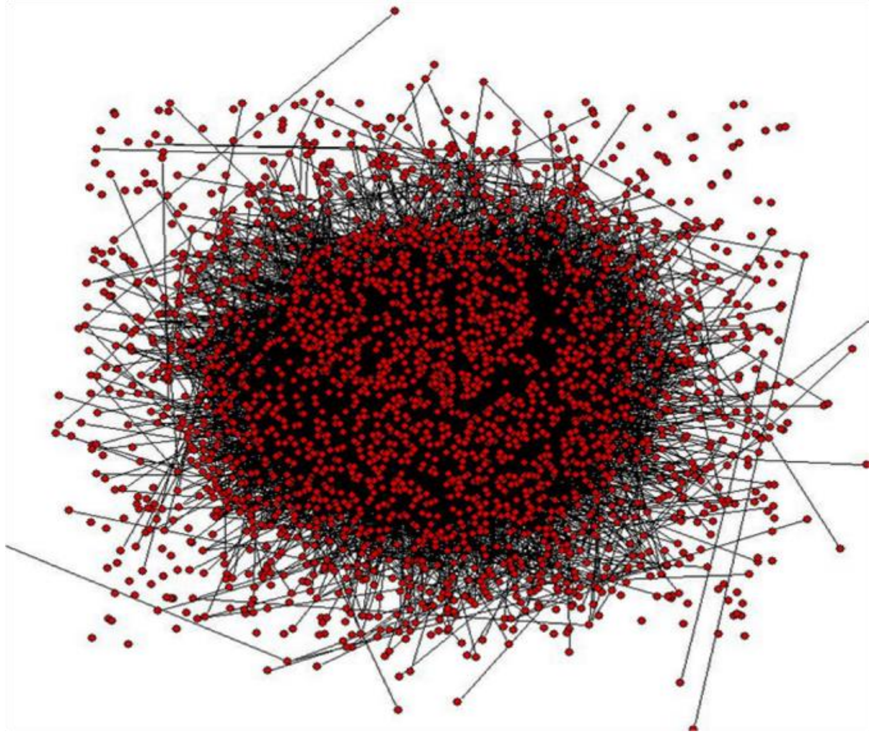
Imitation…… the best form of flattery



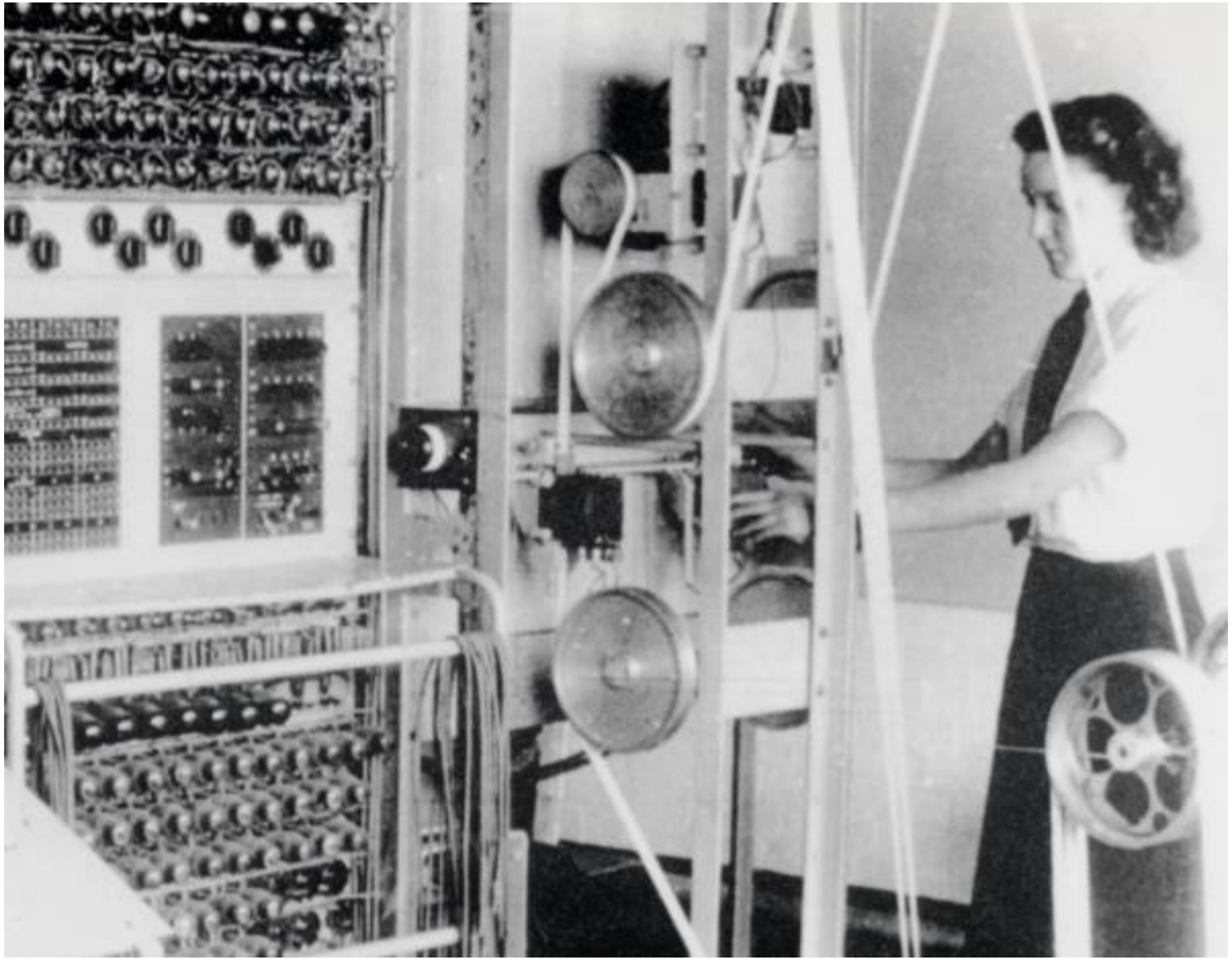
“The view that machines cannot give rise to surprises is due, I believe, to a fallacy to which philosophers and mathematicians are particularly subject. This is the assumption that as soon as a fact is presented to a mind all consequences of that fact spring into the mind simultaneously with it. It is a very useful assumption under many circumstances, but one too easily forgets that it is false. A natural consequence of doing so is that one then assumes that there is no virtue in the mere working out of consequences from data and general principles”

Turing “Computing Machinery and Intelligence” 1950

However complicated a machine we construct, it will, if it is a machine, correspond to a formal system, which in turn will be liable to the Gödel procedure for finding a formula unprovable-in-that- system. This formula the machine will be unable to produce as true, although a mind can see that it is true. And so the machine will not be an adequate model of the mind



JR Lucas "Minds, machines and Godel"



“Most problems I have spent my life studying are uncomputable”

(Joseph Sifakis)

The Waterfall

- A map "f" from some initial state to some final state where f is injective

- S is a finite sub-set of the initial state and |S|=n

- Then f is a mapping one-to-one to an output set T= f(S) with |T|=n

- Any permutation σ that maps elements {1,….n} to itself allows us to label elements of S and T by integers {1,….n} such that f implements the permutation

- A permutation σ in these circumstances could describe any logical or computational semantic

- The conclusion is that such 'computation' cannot give rise to semantic meaning

(Aaronson "Why philosophers should care about computational complexity")

What Makes Quantum Computers Different?

Conventional computers rely on classical computational principles –

- Using binary codes i.e. bits 0 or 1 to represent information
- They are multi-purpose devices

Quantum computers employ the laws of quantum mechanics –

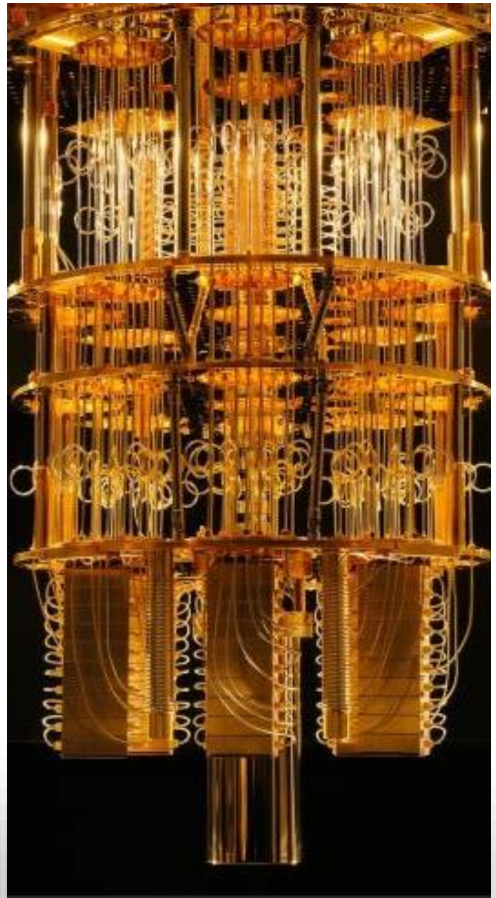
- Using qubits to adopt both 0 and 1 states
- Enabling specific problems to be solved faster and more efficiently

But How?

Three fundamental principles hold the key to this increased computational power:

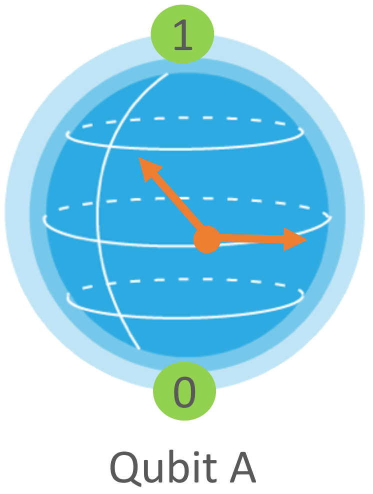
1. ***Superposition***
2. ***Entanglement***
3. ***Interference***

Source: Phys.org

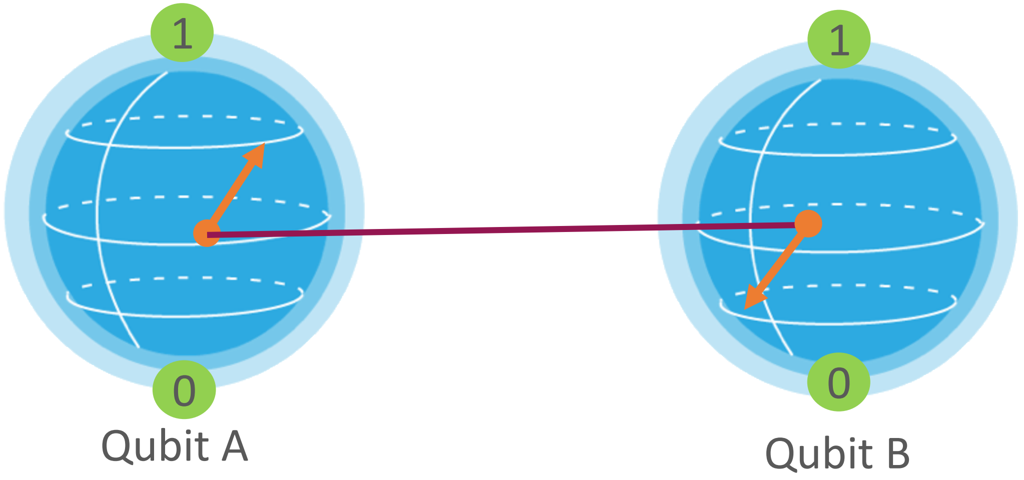


Source: IBM Q

1. Superposition



2. Entanglement



3. Interference

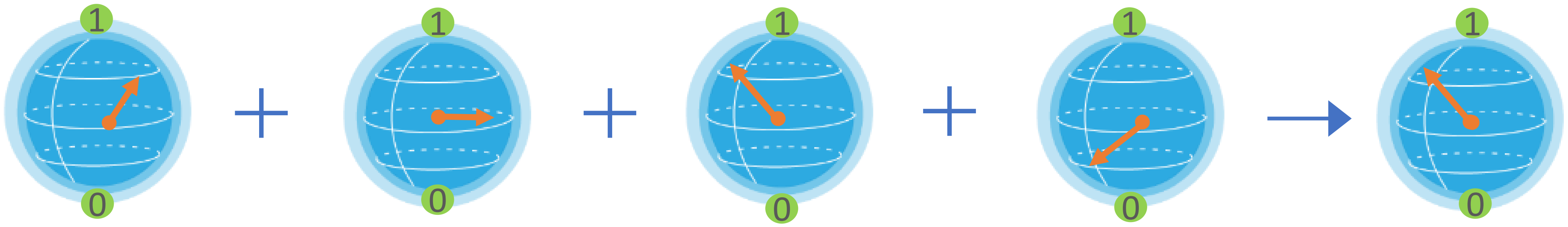
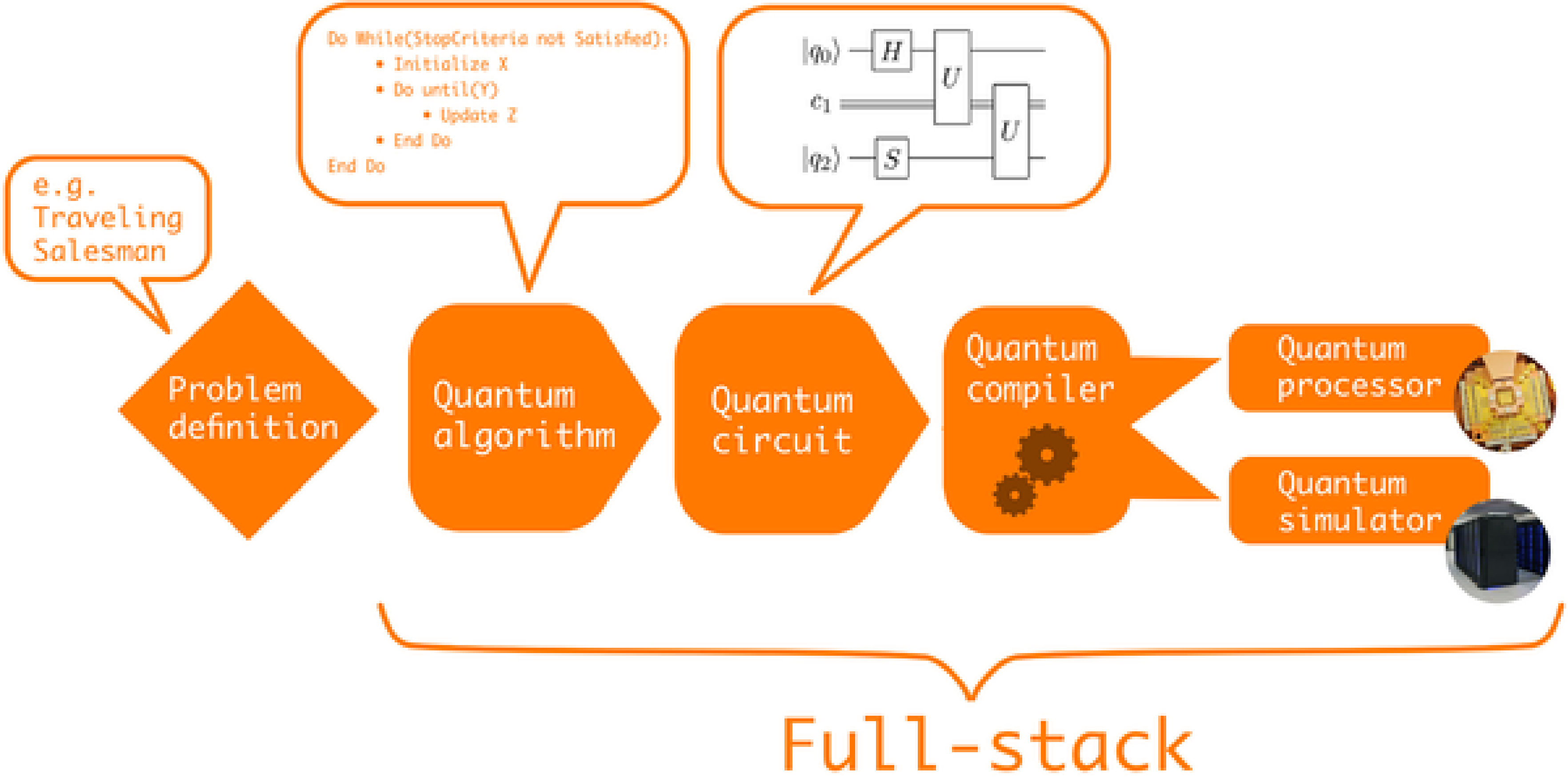


Fig 1. Visualization of a typical quantum algorithm workflow on a gate-model quantum computer.



Fingerhuth M, Babej T, Wittek P (2018) Open source software in quantum computing. PLOS ONE 13(12): e0208561.
https://doi.org/10.1371/journal.pone.0208561
https://journals.plos.org/plosone/article?id=10.1371/journal.pone.0208561

PLOS | ONE

Applications and Anticipated Timeframes

Racing Team

Build superior QC network
Launch new offerings

Riders

Engage with QC ecosystem
Leading own effort

Followers

Participate in QC networks
Gain Experience

Observers

Monitor QC ecosystem
Analyse business potential

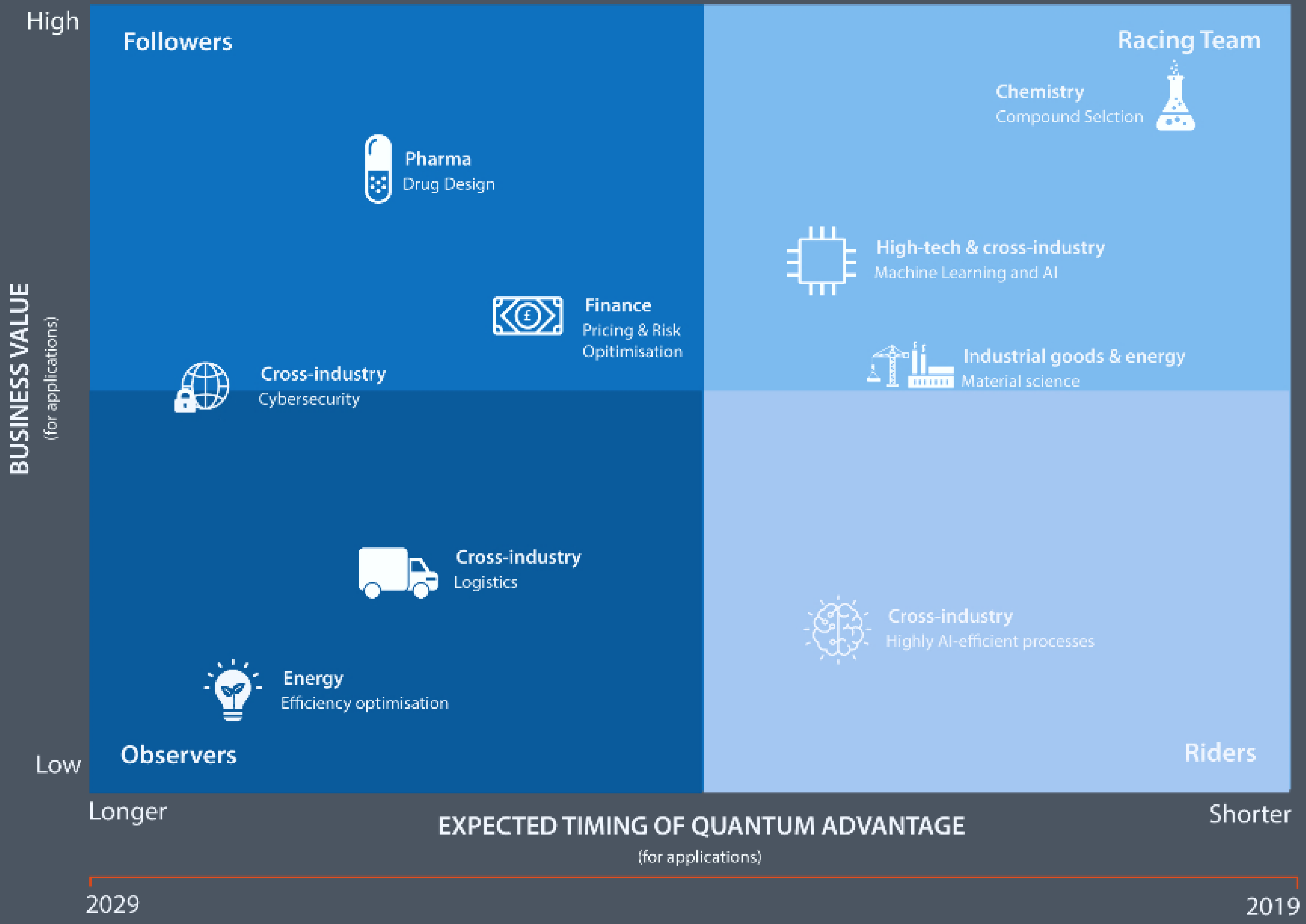


Image Source: Boston Consulting Group (BCG)

Breaching the Extended Church Turing Thesis

"….that every physical process can be simulated by a deterministic or probabilistic Turing machine with at most polynomial overhead"

Complexity-Theoretic Foundations of Quantum Supremacy Experiments

Scott Aaronson* Lijie Chen†

Abstract

In the near future, there will likely be special-purpose quantum computers with 40-50 high-quality qubits. This paper lays general theoretical foundations for how to use such devices to demonstrate "quantum supremacy": that is, a clear quantum speedup for *some* task, motivated by the goal of overturning the Extended Church-Turing Thesis as confidently as possible.

npj | Quantum Information

www.nature.com/npjqi

ARTICLE OPEN

Hierarchical quantum classifiers

Edward Grant[1,2], Marcello Benedetti[1,3], Shuxiang Cao[4,5], Andrew Hallam[6,7], Joshua Lockhart[1], Vid Stojevic[8], Andrew G. Green[6] and Simone Severini[1]

Quantum circuits with hierarchical structure have been used to perform binary classification of classical data encoded in a quantum state. We demonstrate that more expressive circuits in the same family achieve better accuracy and can be used to classify highly entangled quantum states, for which there is no known efficient classical method. We compare performance for several different parameterizations on two classical machine learning datasets, Iris and MNIST, and on a synthetic dataset of quantum states. Finally, we demonstrate that performance is robust to noise and deploy an Iris dataset classifier on the ibmqx4 quantum computer.

npj Quantum Information (2018)4:65 ; https://doi.org/10.1038/s41534-018-0116-9

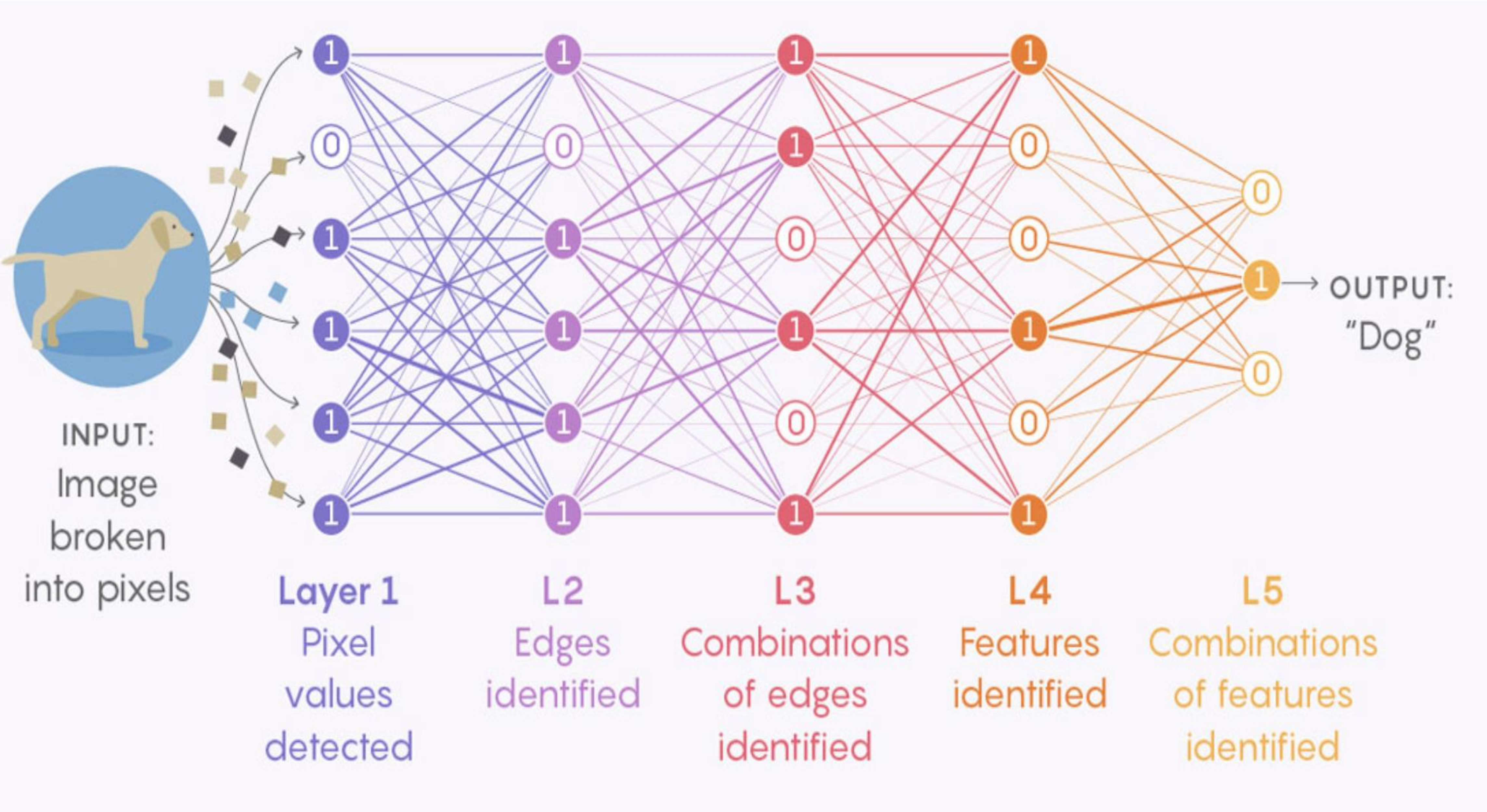
INTRODUCTION

Neural networks offer state-of-the-art performance in a wide number of machine learning tasks including computer vision,

perform qubit encoding using single qubit rotations. For quantum data we assume that the data arrives from another quantum device and is already an entangled amplitude encoded state.

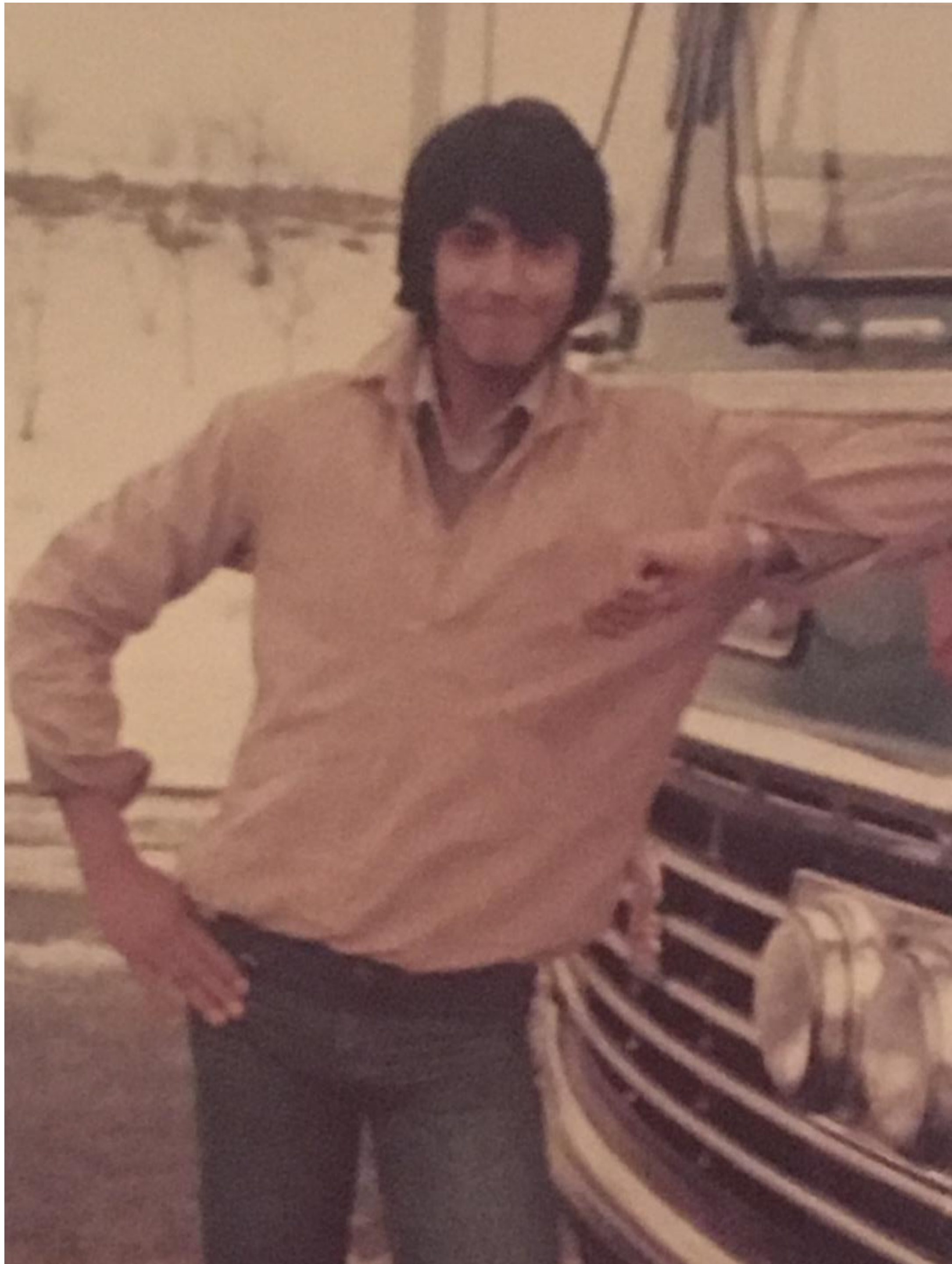
Results signal important advances in the commercialization of Quantum Chemistry applications

Cambridge, October 4, 2018 – Cambridge Quantum Computing ("CQC") is pleased to announce that following extensive experimentation and joint collaboration with JSR Corporation ("JSR"), in a project that commenced in Q3 2017, they have successfully implemented state-of-the-art quantum algorithms to calculate the excited states of molecules that take into account multi-reference characteristics.



INPUT:
Image broken into pixels
Layer 1
Pixel values detected
L2
Edges identified
L3
Combinations of edges identified
L4
Features identified
L5
Combinations of features identified
OUTPUT:
"Dog"

What, exactly, are memories ?




Quantum Foundations……
Working in Hilbert Space……
Confronting the basis of our reality ?