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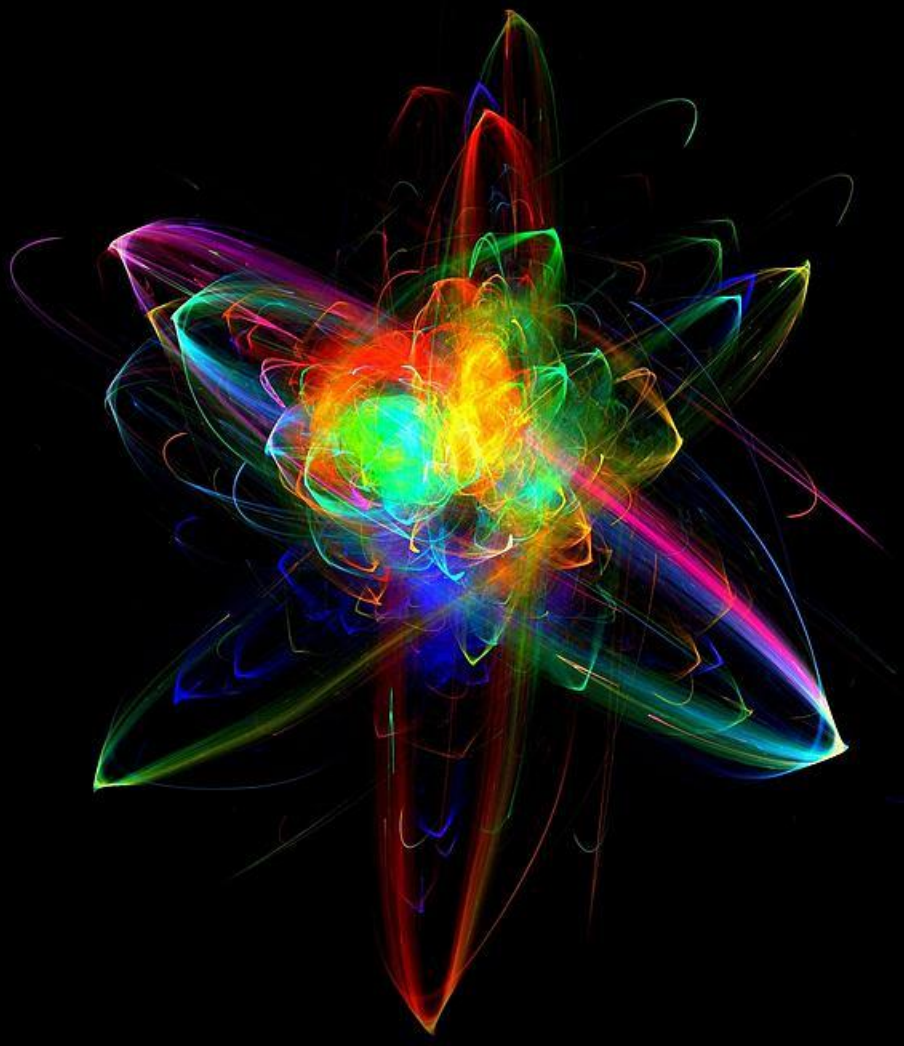


Harvesting Power of Quantum Computing in Agriculture

White paper by QRDLab

Brief Summary

With the recent developments quantum computing is no longer just a theoretical concept but a palpable for enterprises and has a great potential in delivering great business value by solving complex problems in a very efficient way. The marketplace is growing rapidly and companies like Google, IBM, and Intel have all been investing considerable sums into quantum computing for several years. In a survey Nature found that in 2017 and
2018 quantum technology companies received at least $450 million in private funding—more than four times the $104 million disclosed over the previous two years.

This delineate article deals with the science behind quantum computers, the different kind of problems faced in the agricultural industry and possible use cases of quantum computers in agricultural industry.

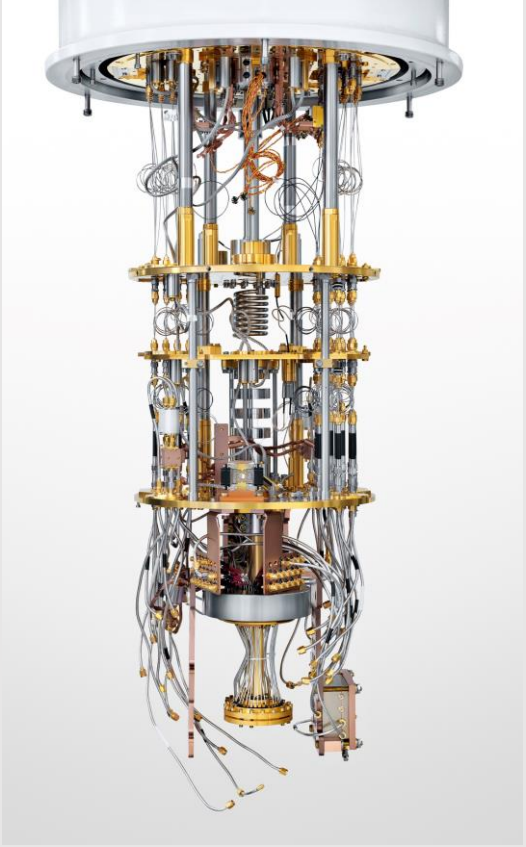
What is a Quantum Computer?

Quantum computers are exponentially more powerful than its classical counterpart, it outperforms the most advanced type of modern digital computers.

Quantum computers relies on the principles of Quantum mechanics and uses quantum bits (qubits) which are different from the classical bits, while classical bits hold values of either a 0 or a 1, qubits on the other hand can be in a superposition of 0 and 1 at the same instant of time.

However, they won't wipe out conventional computers, though. As, using a classical machine will still be the easiest and most economical solution for tackling most problems. But quantum computers promise to power exciting advances in various fields, from materials science to pharmaceuticals research.

Companies are already experimenting with them to develop things like lighter and more powerful batteries for electric cars, and to help create novel drugs.



Quantum chandelier

RIGETTI COMPUTING
JUSTIN FANTL

What's in a qubit?

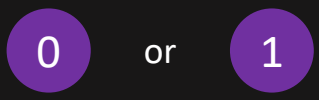
Just as there were different transistor designs in the early days of computing, there are currently many ways to make qubits. Google and IBM both use a version of the leading method, a superconducting transmon qubit, of which the core component is a Josephson junction. This consists of a pair of superconducting metal strips separated by a gap just a nanometer wide; the quantum effects are a result of how electrons cross that gap.

More on Qubits

The basic building block of a quantum computer is known as a qubit or quantum bit. Unlike ordinary bits qubits doesn't hold discrete values of 0 or 1 at a time but rather it can hold value of both at the same time using a very cool property of quantum mechanics known as **"Superposition"**.

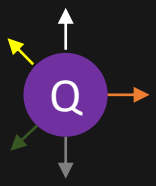
Quantum Superposition

Classical Bits



- **Classical Bits** are **discrete** which means they are either 0 or 1.
- **Classical Bits** are also **deterministic** which means the same operation on a bit will result in the same result

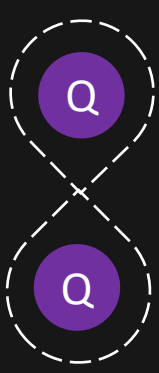
Quantum Bits



- **Quantum Bits** are **continuous** which means they are superposed and holds a value of both 0 and 1 at the same instance.
- **Quantum Bits** are also non-**deterministic** which means the same operation on a qubit will never result in the same result and is totally probabilistic.

The information processing in quantum computers are very different from classical computers, while, in a classical computer bits are processed sequentially, but, in the case of a quantum computer information is processed by using the **"entanglement property"** of quantum bits due to which changing the state of one qubit influences a change in the other qubit regardless of their physical distance. This property of quantum computers to intrinsically converge on the right answer to a problem very quickly making quantum computers efficient and faster than their classical counterparts.

Quantum Entanglement



Two entangled qubits

Measuring the value of one qubit breaks the entanglement and collapses both the qubits

Problems faced by Agricultural Industry

1. Difficulty in finding cheap alternative fertilizers for nitrogen fixation which is affecting the world hunger rate.

2. Complex agricultural optimization problems which hinders efficiency, like production scheduling problem, crop optimization problem, transportation problem and flow capacity problem.

3. Another complex and tedious task faced by the agricultural industry is weather forecasting.

4. Worker schedule optimization is another complex optimization problem faced by the agricultural industry.

5. Difficulty in managing global food manufactures and government planners to come up with optimal planning involving multiple firms with different constraints

How emerging technology like Quantum Computing can drive towards sustainable agriculture?

In data-driven age of computing, even the oldest and pre dominating industry of mankind agriculture is in the era of handling enormous data. Agricultural farms are aiming at navigating in a big data eco system in order to optimize the conventional mode of operation using advent of high emerging technologies like machine learning, artificial intelligence, artificial intelligence and the most recent one, quantum computing. Moreover, optimized planning lead to a more sustainable and eco-friendly infrastructure causing less damage to earth.

Quantum Computing boosts up Agricultural industry in alliance with conventional AI, Big Data and IoT

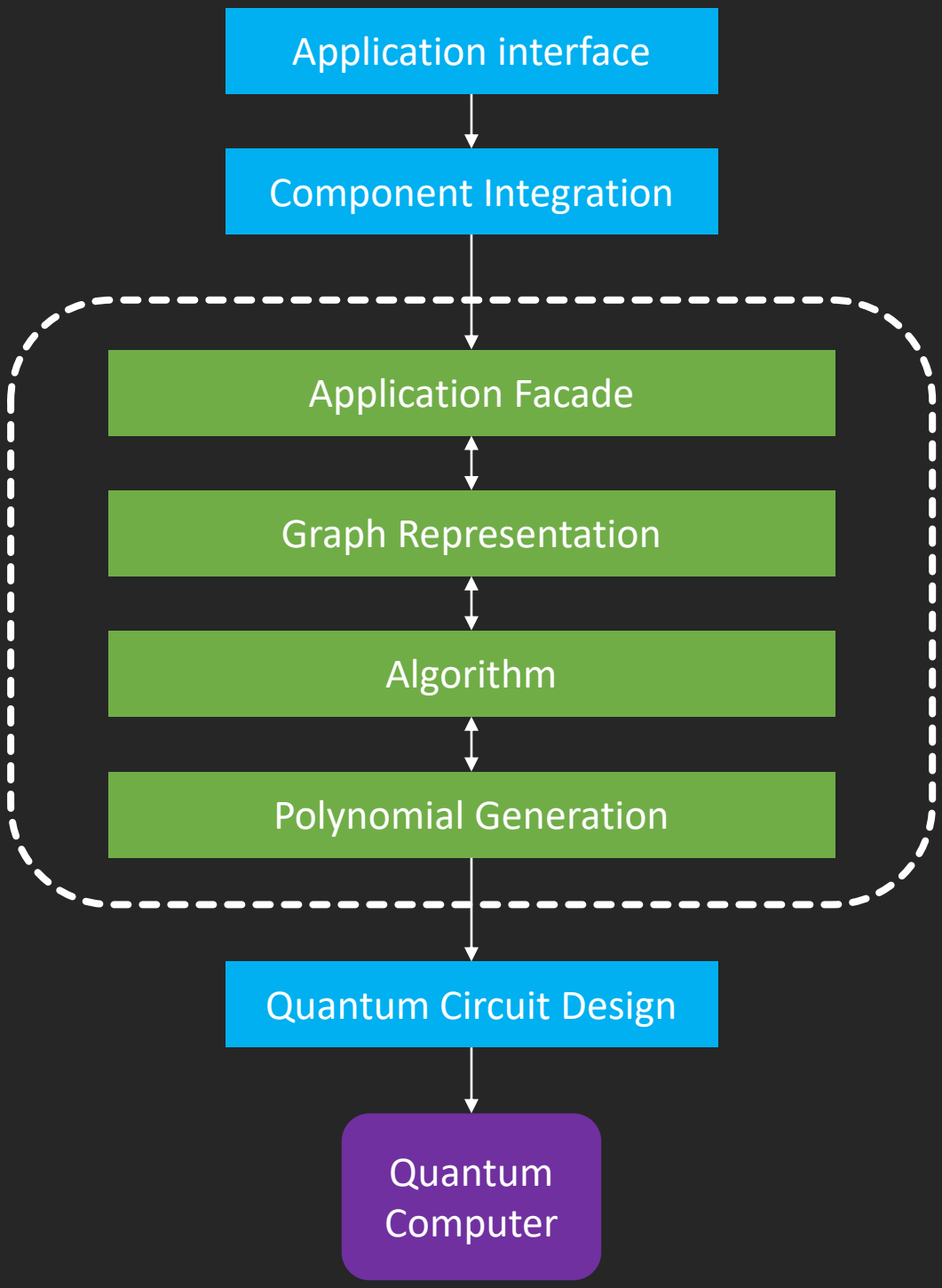
Classical Quantum hybrid approach in agriculture

Managing a central and hyper-local geographical Information System (GIS) is one of the most challenging areas in agriculture industry. A GIS is a centralized platform to provide a knowledge base by integrating common database operations like query and statistical analysis with unique visualization and geographic benefits offered by maps. GIS used in agriculture deals with a detailed information regarding soil structures, weather patterns, crop varieties and their inter-relationship. Building a hyper-local GIS and developing variable rate technology might accelerate the throughput of crop production and lessen the overall cost incurred in management of land resources. GIS has the capability to analyze soil data and determine suitable mapping between a crop variety and appropriate soil to plant that crop. Thus help in maintaining soil nutrition so that plant get maximally benefitted. A Quantum Enabled AI architecture is used as a solution which is used to apply GIS in agriculture and maximize throughput in production.

Quantum–Information Processing (QIP) enabled Big Data Analytics in Agriculture

Big Data systems are often built for farmers to manage the big data coming from IoT network. Big data is a term associated with data that is beyond the storage capacity and processing capabilities of a classical computer and handling voluminous, incremental and complex datasets of data to gain insight from them is quite tedious and big challenge at hand. The present world of big data is a threat to classical Machine learning algorithms due to pace of incrementally growing rate of big data as these are intractable for a classical computer to solve . However, Quantum Machine Learning (QML) gives an exponential speed up over the current state of the art of computing. Quantum enabled Artificial Neural Networks (QANNs) can add real parallelism and dramatically impact the big data processing in the agricultural industry.

Architecture of the proposed model



Use Cases of Quantum Computer in Agricultural Industry

Fertilizer Generation

Most of all the fertilizers contain ammonia however they are very expensive. Therefore, efficient manufacturing of ammonia or its substitute is vey much needed and will result in cheaper and less energy-intensive fertilizer generation. However, there hasn't been substantial progress because the number of possible catalyst combinations to do so is infinite. A Quantum computer can quickly analyze and come up with a catalytic combination, which is beyond the abilities of our largest supercomputers.

Agricultural Optimization

Since quantum computer are very good with optimization problems and gives an exponential speed-up over its classical counterparts. So, using a quantum computer one will get very effective solution to production scheduling problems, crop optimization problems, transportation problems and flow capacity problem. Not only that government and big corporations will be able to optimize and manage the agriculture of a large geographical area.

High-Precision Weather Forecast

Agricultural Industry is highly impacted by the weather. High precision weather forecast is a complex task even for the best in class super-computers due to the high dimensionality. But, quantum computers reduce the complexity by a huge margin and gives very accurate forecast which can help the agricultural industry by huge margin.

Worker Scheduling Optimization

Agriculture is heavily dependent on man power and optimizing the schedule of workers can lead to huge profit of the agricultural Industry. As mentioned before quantum computers vitiate classical super computers when it comes to optimization problems hence can be very helpful for the agricultural industry.

Summary

In spite of nascency of quantum technological advancement including developing qubits with longer coherence interval, scaling qubit count incorporating quantum error correction and many others, quantum computers can unfold mysteries and can lead to revolutionary breakthroughs in discovery of new materials for agriculture, agrochemical discoveries and in devising quantum-enabled artificial Intelligence algorithms. Quantum Invasion in agriculture will diversely range from molecular modeling to analyzing genomics data for plants, animals and soil microbiome. This real-time quantum-enabled data analytics will shape the horizon of food and agricultural research and step towards this new era of computing.

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