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A Review on Quantum Computers and Machine Learning

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Abstract- Pattern can be learned from existing data to provide sense to the previously unknown data, this is possible only with the help of Machine learning. As part of both artificial intelligence and statistics, machine learning algorithms process large amounts of information. Machine learning refers to usage of computers to infer data based on knowledge. In the big data analysis huge amount of update data should be deal with the highly sophisticated machine learning algorithms . Quantum computing may improve classical machine learning algorithms if we deal with big data. The quantum computer works on the principle of translating stochastic methods into the language of quantum theory. This paper is focusing on the brief review on quantum computers and machine learning.

Keywords: Machine learning ,page ranking artificial intelligence.

I. Introduction

The basic features of a conventional computer have equivalent facial appearance in a quantum computer. As an alternative of bits, a quantum computer has quantum bits or qubits .Qubits work in a predominantly fascinating way.Where a bit can store either a zero or a 1, a qubit can store a zero, a one, both zero and one, or an infinite number of values .It can be in multiple states at the same time. Qubits use superposition to represent multiple numeric values simultaneously in a similar way. Just as a quantum computer can store multiple numbers at once, so it can process them simultaneously. Quantum computer working in parallel instead of serial[6].

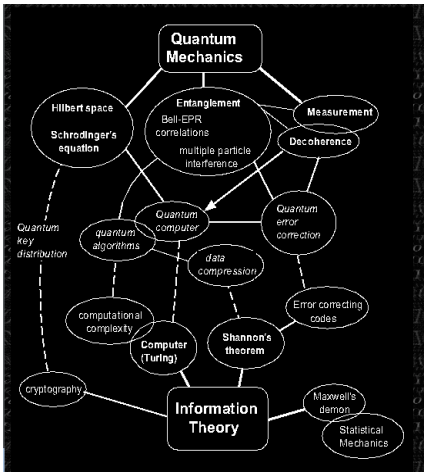

Figure 1.Relation between Quantum mechanism and Information theory

1.1 Evolution of Quantum computers

Table1.Showing the details of evolution of Quantum computers

Year	Name of the person	Functionality
1965	Richard Feynman Physicist	Developed the first atomic bomb which proposes significant theories of quantum thermodynamics.
1980	Feynman and others	Investigated the process of generalizing the conventional information science concepts to quantum physical processes.
1985	David Deutsch	Presented a paper describing about universal quantum computer
1994	Peter Shor	Proposed a algorithm Shor's algorithm which was based on

		Qubits and superposition to find prime factor of an interger
1995	National institute of Standars and Technology ,Calofornia	Performed experiments with magnetic fields on trapping particles and cooled to quantum state.
1996	A team of University of California,MIT,Hardvard University and IBM researchers.	Used nuclear magnetic resonance (NMR) which manipulates quantum information in liquids.The team deloped a 2-bit quantum computer made from thimble of chioroform. Input consists of radio frequency pulses in to the liquid containing ,in essence ,the complied program to be executed.
1998	International team of researchers	Proposed quantum teleportation process. This process processes implications for data transfer and networking among quantum particles in quantum computing

1.2 Basic terms related to Quantum Computers

The building blocks of Quantum computer are qubits ,they are physical components[1,2] so small. They operate by the rules of "**quantum**physics."

Quantum **"**Quantum is the smallest possible unit of any physical entity. Quantum theory is characterized by finding the probability of, and not the exact location of, a particle at a given point x in space."

Qubit **"**a quantum computer uses quantum bits, also called 'qubits' to perform operationsas shown in figure2".

Qubits can be represented by:

- where |1> and |0> are the excited state and ground state an electron orbiting a nucleus.
- where |1> and |0> are polarizations of the photon.

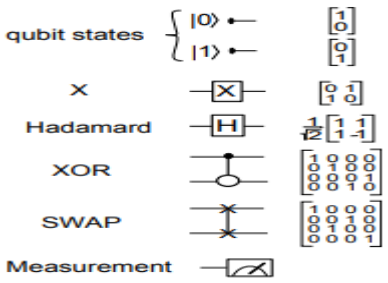

Figure2. Components associated with quantum circuit model .

Superposition The phenomenon of existing in the state of 0 and 1 at same time is called 'superposition'. In the same way a particle can exist in multiple quantum states, once the particle's energy or position is measured , its superposition is lost so it exists in only one state.

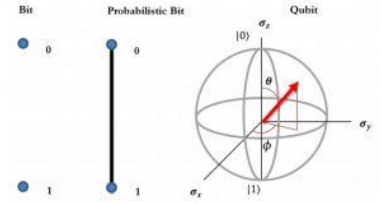

Figure3 . The qubit shown as a pair of complex vectors pointing with unit sphere.

Entanglement 'Quantum entanglement' is the phenomenon in which quantum particles interact with each other and are described with reference to each other, not independently, even if the particles are separated by a large distance.

The above sections in the introduction has given the detailed introduction of quantum computers .Section2 of this paper is discussing about the comparisons of Quantum computer and machine learning.Section 3 is the overview of the observations on quantum computers and machine learning algorithms.Section 4 is about summary of the paper.

2.Quantum Computers Vs Machine learning

Machine learning is making the computer or application to learn themselves. As mathematics reached the level of time travel concepts but the computing is still running under classical mechanics. The companies understood, the computing field must have a change from classical to quantum, and they started working on the big Quantum computing field, and the market named this field as Quantum Information Science[3] .

Figure4. Conceptual idea of Machine learning algorithm

As machine learning follows the learning model as shown in figure4 . The input data is experience and the information the algorithm extracts is , knowledge, as shown in Figure5.

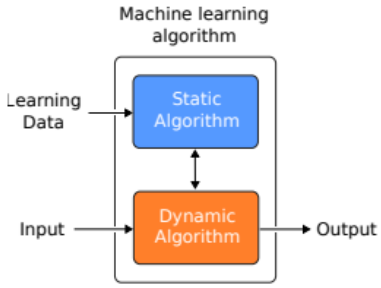

Figure5. Machine learning algorithm operation scheme.

Machine learning algorithms can be understood as internally composed of two algorithms. The dynamic algorithm have a wide range of possible behaviors and is the responsible of solving the desired problem, giving us the correct outputs for the inputs. The static algorithm fixes the behavior of the dynamic one based on the experienced data and some extra learning data.

Finding eigenvalues and eigenvectors of large matrices[9] Quantum PCA is exponentially faster than the a linearly –scaled classical algorithm. This method can found the can reveal the quantum eigenvectors associated with the large eigenvalues.

Finding nearest neighbours on a quantum computer[9]: The quantum algorithms for computing nearest neighbours uses supervised , unsupervised learning .In this method it considers the upper bound as the input data which is required to compute distance metrics like the Euclidean distance and inner product.

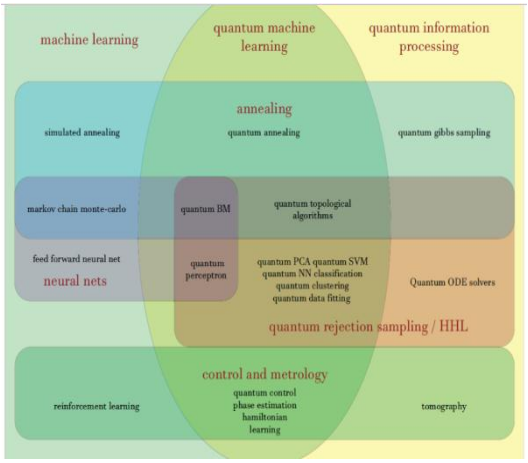

Figure6. Machine learning and Quantum computing

Scientists trained a quantum learning machine[10] to execute binary classification of qubit states into 0 and 1, with the classical memory growing only logarithmically with the number of training qubits. It is performing efficiently beneath a altering symphony of a large-enough training set. Relation between Machine learning and Quantum computing is shown in figure6[7].

3.Observations

At a Conference in 2017, Microsoft CEO Satya Nadella[8] used the analogy of a corn maze to explain the difference in approach between a classical computer and a quantum computer. In trying to find a path through the maze, a classical computer would start down a path, hit an obstruction, backtrack; start again, hit another obstruction, backtrack again until it ran out of options. Although an answer can be found, this approach could be very time-consuming.In contrast, quantum computers "unlock amazing parallelism. They take every path in the corn maze simultaneously." Thus, leading to an exponential reduction in the number of steps required to solve a problem.The parallelism comes from the concept of 'qubit', 'superposition' and 'entanglement' derived from Quantum Physics.

Table 2. Differences between machine learning and Quantum approach

S.no	Machine learning method	Quantum approach
1	k-nearest neighbor,support vector machine, k-means clusterin	Efficient calculation of classical distance on a quantum computer[4,5]
2	Neural networks ,decision trees	First explorations of quantum models
3	Bayesian Model ,hidden Markov models	Reformulation in the language of open quantum systems

4. Summary

A Quantum computer exploits quantum –mechanical interactions in order to function,possesses incredible potential to manipulate data in ways unattainable by machines today.Key ingredients of quantum mechanics Quantum mechanics has certain bizarre features which do not occur in standard, or "classical" physics, such as: 1. Superposition. If a system can be in state A or state B, it can also be in a "mixture" of the two states. If we measure it, we see either A or B, probabilistically. 2. Collapse. Any further measurements will give the same result. 3. Entanglement. There exist systems of multiple parts which cannot be described only in terms of their constituent parts. 4. Uncertainty.

Quantum Machine Learning is the combination of interdisciplinary region combine Quantum Physics with Machine Learning(ML). In view of Richard Feynman Quantum computer is "Things on a very small scale behave like nothing you have any direct experience about or like anything that you have ever seen" . The disadvantage of Quantum computers building a large-scale quantum computer is extremely challenging because of decoherence. If a quantum computer interacts with the outside world and is subject to noise, it can lose its "quantumness" and behave like a classical computer.

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